The Synapse

Oberlin College Science Magazine

The Science of Neuromarketing

staff list

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Winter Term in Belize

By Elie Goldberg

Photo by Elie Goldberg

…Sneeze…

…Sneeze…

Something had irritated my sinuses. "That's the Jo-Grind," Chico told me, struggling to speak through his giant smile. The Belizean sun reflected off of his golden tooth.

"And what's the 'Jo-Grind?" I asked.

At this point we were three miles into the transect, our observational hike through a jungle in Belize, which is a country located on the northeastern coast of Central America. The jungle remained at constant density, not growing thicker or sparser. The morning sun was quickly transitioning into the notably more powerful midday sun, and Chico was looking less weary with every stride. For Chico, this was just another walk in the park — no sweat, no constant need for water, no fatigue — shocker.

"The Jo-Grind! Elie! How you not know the Jo-Grind… It's, you know. That guy, man."

I could already tell that this was going to be one of those lessons in Belizean slang, which took Chico 40 minutes to work through using his Spanglish vocabulary.

"Now you will know. The Jo-Grind is always around," he continued, "he's the one that steals your lover from you. That takes them when you're gone. When you're away in the jungle."

"Why would someone sneeze when the Jo-Grind takes their lover?" I asked.

"You know how if your kid gets hurt or sick but you're not there, you just feel it. You just know. Its the same with the Jo-Grind. When the Jo-Grind gets close to your lover, he sends you a sneeze! That's the Jo-Grind!"

I couldn't contain my laughter. His blank smile was the best part — he was completely unaware of my confusion. It was clear that he felt his explanation had been rational and sufficient.

Our laughter was only a momentary escape from the harsh reality before us. We had stumbled across another fallen mahogany tree. Not fallen — butchered. This one was much taller than our first of the morning and just as thick, about three feet in diameter. Yet, bizarrely, no parts had been hauled away to make furniture for naïve customers. Sliced through with just one staggered cut, indicative of a hand held chainsaw, the mahogany just sat there, felled but otherwise untouched. Why? Perhaps for fun, or out of arrogance, or maybe just out of boredom.

The specific project I was helping Chico with, however, was more concerned with investigating the poaching of small mammals and birds than illegal logging. While the Chiquibul Rainforest of Belize faces innumerable threats — illegal logging, poaching, cutting of specific plants, strip mining, etc. — there are very few organizations working to protect it. Consequently, one NGO, Friends for Conservation & Development, with which I volunteered this past winter term, must cautiously allot their limited time and resources. This translates to about six field researchers working two weeks each month. The NGO's only active field project is Chico's, concerned with investigating the illegal poaching of specific birds and small mammals.

About twenty minutes later, we heard a rustling sound. Its direction of origin was unclear.

Chico signaled for me to get down and be quiet.

This is the moment in time where your mind begins racing with questions. You are 100 miles into one of the densest, most remote, and biologically diverse rainforests in the world. You are accompanied by just one other fellow

A Winter Term in Belize

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researcher. You hear leaves crunching. The possibilities are endless and hardly limited to just animals.

You know that it's most likely a raindrop, a tiny mouse or swallow, or a fallen branch disturbed by the wind. But another part of you knows it could be something less innocuous. You instantly look straight up into the canopies, following the sound, searching for movement. Howler Monkeys? Scarlet Macaws? Toucans? Coati? But then the movement seems like it's coming from behind you, closer to the jungle floor. You glance at Chico to see if he's been any more successful at triangulating the sound — he usually has been.

Chico stared directly into the heart of a bush, picked seemingly at random, about ten feet away. He immediately filled one cheek with air, hit it with his fist, and forced the air to come out of his lips — making a hilarious spitting sound. He did this over and over again. For a split second I thought he might have lost it.

After sitting quietly for about a minute, a few shapes begin to move closer. As they shift into focus, I immediately recognize them as a group of collared peccaries, which bear a striking resemblance to Pumba, though they are quite a bit hairier.

While Chico continued to make his strange Pumba-calling spit-sounds, I blissfully sit and observe as a family of eight peccary waddle closer to investigate.

I take my pen out of my shirt pocket. Species – Collared Peccary; Abundance – 8; Animal Azimuth – 378°; Sex – Males & Females; Activity – Foraging; Method – Direct Sighting.

The Chiquibul Rainforest is about 500 square miles in size, which occupies about 7.7 percent of the mainland of Belize. This rainforest is home to hundreds of discovered and undiscovered Mayan ruins, the largest cave system in Central America, and countless species of mammals, birds, insects, amphibians, and flora – many of which are now endangered. A few parts of the Chiquibul still have not been fully explored, and new species are constantly being discovered. Just last year, a never-before-seen species of grasshopper was identified by a team from the University of Illinois.

About six months ago, Friends for Conservation and Development (FCD) began functioning as the main supervisor of this Belizean rainforest. Working alongside the Belizean Defense Force, the Belizean Forestry Department, and other government affiliations, about twenty people (1fifteen in an office and six in the field) struggle to protect 500 miles of threatened wildlife and forestry. The help that FCD receives from the Belizean government, specifically armed troops and money, are irregular and unreliable.

Two hours later, we completed our long hike back to the Las Cuevas Research Station. The research station is a complex of about ten small wooden buildings — complete with living quarters, a small laboratory, a kitchen, and a tool shed. Running water is supplied by a beautiful on-site cave, which is part of the largest cave system in Central America. FCD took over the research station about seven years ago, when its previous owner passed away. Las Cuevas greatly benefits from visiting researchers, students, and tourists. Given their minimal manpower and funds, volunteer trips can be enormously impactful and helpful to the cause. Starting this spring, FCD will continue their scarlet macaw monitoring program. Through this program, researchers climb hundreds of feet into macaw nesting trees, gather research on macaw mating progress, and try and protect the chicks from being stolen for the Guatemalan pet trade.

As I crawled up the stairs to our kitchen building, I immediately recognized the increasingly familiar lyrics of "Tú estás aquí" by Jesus Romero, the one CD at the research station. Richard and Boris were already kneading the tortillas and boiling the beans. Chico and I sat down on the porch and began the terribly difficult process of allowing the warmth of the afternoon sun, sounds of the jungle, smells of fresh tortillas, and the hilariously corny Hispanic church music wash over us, as another exhausting day of fieldwork came to an end.

Editor's note: Rafael Manzanero, the director of FCD, will hopefully be visiting Oberlin in the future to give a lecture on the work of FCD and meet with students about possible research and volunteer opportunities. Be sure to look out for his upcoming lecture!

Science and Society

By Anna Dardick

Decades ago, a doctor withdrew a sample of endlessly replicating, cancerous cells from Henrietta Lacks without her consent. Today, these HeLa cells predominate in lab studies and have resulted in a myriad of scientific breakthroughs and profits for pharmaceutical companies and academic institutions, while Lacks' family languishes in poverty. Even after a recent bestseller brought the HeLa controversy to light, this year, a scientist sequenced the genome of the cell and published it on the internet, essentially exposing Lacks' (and her family's) genetic information without any permission. The sequence was eventually removed, but the question remains: Does scientific advancement justify the elimination of human and social concerns? The irony is that many scientists pursue cures for devastating diseases to help people, while often taking advantage of HeLa cells or, as was common through mid-20th century, of test subjects. The more meaningful question may be: How can we make scientific advances while taking social histories and structures into consideration? I argue that science is most influential when it takes the human element into consideration, whether in the development of knowledge or the communication of said knowledge to a general audience.

In the United States, we tend to consider science as "truthier" than other truths. I think that we should critically review that assumption –– often, as in cases of unfolding diseases, community and individual knowledge should be equally considered. Science is *a* way of knowing, not *the* way of knowing. Science is a tool that can be used for erasure of human willpower and knowledge (as in the case of Henrietta Lacks), or may be wielded to empower society with another mode of understanding.

Female Power & Agency In Animal Behavior

By Nicole Le


Stella Rosen

In a dark corner of an Australian forest, a young male bird purposefully places a small brown pebble at the door of his constructed bower. The bower bird will continue to carefully curate items from the forest to decorate the bower in desperate hopes that a female will like it when breeding season arrives. She has final say in whether or not he will pass on his genes through her offspring. Instances of female power and agency in animal species are incredibly varied, and constitute a vast spectrum of sexual and social behaviors. By understanding more clearly the different kinds of sexual relationships that exist in the natural world, we can illuminate the ever-present conversation surrounding our own sexual relationships.

Sex in the animal world serves many different purposes. At the most elementary level, sex is the means by which individuals pass on their genes. In nearly every species, the female egg is rare compared to the commodity of male sperm. Because of these different investments, females are generally referred to as the 'choosy' sex in animal behavior, constantly assessing their male counterparts for quality. These strategies take on a number of different forms. Razorbill birds and burying beetles engage in female-enforced monogamy, where females physically constrain male extra-copulatory behavior. However, the best mating strategies for several other species of birds involve male and female extra-pair copulations: sexual interactions outside of the socially monogamous pair they've established for the breeding season.

Polyandry is a mating system where females have sole access to several males. In some animals, such as "eusocial" bees and naked mole rats, a queen is the only breeder in the colony for the entirety of her life. Relatedly, there is arena mating, where males establish small symbolic territories in close proximity to each other, and females essentially come and shop around. Several bird species engage in this system, as do African ungulates such as the antelope and Uganda kob. Males set up a display of some kind, whether it's a feather display, dance display, or bower display, and give females the ability to assess several males at once.

One of the most fascinating instances of female power in the animal world is a phenomenon called 'cryptic female choice', in which a female physiologically controls her reproductive organs during or after sex. Some female birds up-regulate the manufacture of testosterone in their bodies only after mating with especially attractive males (a proposed indicator of genetic strength). The testosterone is absorbed by yolk and leads to larger chicks who will beg for food more loudly, grow faster, and be more likely to become dominant individuals after fledging. Some female polyandrous birds are physiologically equipped with sperm storage tubules that allow them to choose which male's sperm will ultimately fertilize their eggs. Though she will mate with several males and deposit eggs in each of their nests, every egg will have been fertilized by a first, presumably, best male. Similarly, female moths can take in sperm packs from several males, but will only use sperm from the largest pack to fertilize.

Interest in this topic has developed more recently, and is a compelling indicator of our small understanding of what constitutes "natural" male and female relationships. Though the most cited and well-studied examples of the particular relationships in this article often come from bird and insect species, there are instances of several other categories of female power and agency in mammals, reptiles, and fish that include matriarchies, hermaphrodites, and social sex. In beginning to better understand the spectrum of sexual and social behaviors in the natural world, we gain a powerful and humbling perspective on the role of humanity in sex, relationships, and power.

The Mind of a Child


Ben Garfinkel

By Ben Garfinkel

Unlike most other organisms on the planet, human babies come out practically useless. They can't walk, talk, or contribute in any tangible way to society at large, save a starring role diaper commercials until years after birth. Young children are clearly learning during infancy, but how does this learning occur? Put simply, what is it like to be a baby?

If one seeks for a glimpse at the true subjective experience of a child, she is unlikely to find it through empirical means, but that has not prevented philosophers and psychologists alike from trying. The 17th century Dutch philosopher Baruch Spinoza posited that young children know "little of [themselves], or of god, or of things," implying that infants are nothing more than bundles of reflexes. The famous early 20th century child psychologist Jean Piaget considered young children to be memory-deficient; that is, constantly living in the moment with no knowledge of past or future. These kinds of ideas permeated the scientific literature throughout the 20th century, spilling into the 1990s. During this period, a new school of thought emerged — an entirely novel hypothesis about the nature of the young mind.

Championing these new ideas about child thought is Dr. Alison Goptik, a psychology professor at University of California, Berkeley. Goptik's research, spanning over twenty years, provides strong evidence that children understand probability, intentionality, and causality — characteristics which may contribute to children's exceptional ability to learn at an accelerated rate.

Babies seem to understand more about the minds and actions of others than scientists previously thought. This finding is supported by decades of research from Dr. Goptik's lab. In 1977, for example, she performed a simple experiment wherein 14 and 18-month-olds were presented with broccoli and crackers. As one might expect, the overwhelming majority of both groups chose the crackers. Next, Goptik expressed disgust towards the crackers and adoration towards the broccoli, subsequently observing which of the foods the children offered her. While the 14 month olds usually presented her with crackers, the 18 month olds offered her broccoli. This surprising result suggests that 18 month olds are not only aware of subjective experiences separate from their own (also known as "Theory of Mind"), but also possess a thorough understanding of others' wants and desires.

Research indicates that the conceptual scaffolding of a child's mind extends past even theory of mind, into more probabilistic scenarios. Goptik believes that the secret to the spongy mind of a child is a natural knack for conditional probability. One experiment that demonstrates this, involving a bucket of many white balls and few red balls, relies on the finding that babies stare at novel things longer than things to which they are acclimated. The results of the study showed that babies as young as eight months stared for longer when the researcher pulled out an improbable number of red balls (e.g. eight red, one white), than more likely ratios.

As it turns out, babies employ the same innate intuition during language acquisition, allowing them to learn entire languages almost effortlessly. One study found that after listening to a made-up language for only three minutes, young children could recognize individual words from the language shortly after. This result indicates babies are able to separate words based on the probability that a set of syllables will occur together. The probabilistic learning demonstrated in this study is important for language acquisition because words will not always occur in the same sentence structure, nor will everyone around the infant pronounce the same word identically.

Once you understand probabilities, you can test hypotheses about the world. For example, upon hearing a word, a baby will form a "hypothesis" about how that word is supposed to sound and fit into sentences. As a baby hears a word more often, he can better fit that word into a proper sentence. In the red and white ball experiment, the baby's hypothesis was violated when an improbable number of red balls were pulled from the bucket. Amazingly, babies are able to link some probabilities to others, forming a network of probability, called "Bayesian Networks." These networks, named after the famous mathematician Thomas Bayes, are systems of conditional probabilities wherein random variables (how many red balls the researcher picks out of a bucket) are dependent on static variables (how many balls there are in the bucket). These networks allow for babies to learn and grow, building functional, integrative hypotheses about how the world.

Clearly, babies are smart enough to form and test hypotheses, but why did humans evolve to be fully capable of walking and performing tasks earlier in life? As it stands (no pun intended), humans are virtually useless until many years after birth. However, they have more neural connections (called 'synapses'), and fewer inhibitory neurotransmitters than the adult human brain. This lack of inhibition and increase in connections means that young children can learn and make connections more than adults. It also means that children have a very tough time focusing because they focus on everything. Later in development a neurological process known as synaptic pruning removes the connections deemed less important, thus the difference between a hyperactive kindergarten classroom and a solemn college neuroscience lecture hall.

Encouraging integrative, interdisciplinary learning can induce the same kind of creative learning present in young children. Synaptic pruning is inevitable, but that does not mean that integrative learning and creativity have to stop at puberty.

Advancements in HIV Detection

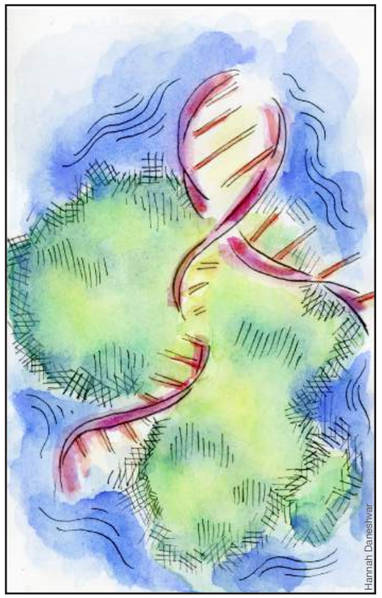
By Rachel Budker

Working in the lab by the light of a green glowing bulb, my mother leans over a sample of dyed RNA strands, which will be run through a variety of apparatus that will tell her if she has effectively multiplied the contents of this test tube by a million times. She will test the success of her experiment by making sure the reactions "cascaded" properly, measuring the size and charge of her synthesized RNA via gel electrophoresis as well as measuring the final concentration of RNA. Later, using computer modeling, she will continue to tweak what is going on in those test tubes. My mother is a part of a team of scientists and engineers that are developing a new point-of-care device for HIV/AIDS diagnostics specifically designed for testing patients in Africa.

Because HIV mutates so rapidly, detecting it is incredibly challenging. It is impossible to detect one molecule of the virus alone, and often a large enough sample is unavailable. The discovery of in vitro polymerase chain reaction (PCR) techniques in the 1970's made it possible to put isolated strands of DNA or RNA (in the case of HIV) into a test tube and mimic the replicative processes happening in the cell. Scientists could take a sample of potentially infected blood, multiply both the healthy and virus-infected cells by millions, and then detect the prevalence of the virus .

Biotech companies have since been working on creating tools that can easily detect and diagnose HIV/AIDS, specifically in Sub-Saharan Africa, where the virus affects 23.5 million people, which is 69% of the total number of people affected worldwide . Humanitarian health organizations have guidelines for such diagnostic tools. For example, the World Health Organization (WHO) has specific detection-limit specifications, requiring diagnostic tools to detect at least 1,000 copies of the virus per 1 mL of blood.

Scientists face many challenges when designing these diagnostic tools. Not only are they operating under the requirements mandated by the humanitarian organizations that oversee them, but also under physical and economic constraints. The device needs to be inexpensive and relatively easy to manufacture; PCR is complicated and costly, making it a difficult technology to employ on a large scale at present. Moreover, patients can realistically give only a finger-prick sample of blood, approximately 100 µl. With such a small sample, it can be quite difficult to


Hannah Daniel-Noar

detect HIV to merit a positive test result.

My mom is among the many scientists trying to develop an appropriate device within this paradigm. Her project has major theoretical challenges because scientists have not yet discovered or developed all the necessary procedures and techniques. As a molecular biologist working on her team at a small start-up company, my mom has had to research, develop, and demonstrate that there is even a way to create such a diagnostic tool. She had to prove that existing processes could be adapted and applied in new ways to create this kind of device.

Using a technique called isothermal amplification, which is similar to PCR but more effective on a small scale, made this part of the process possible. PCR requires thermocycling processes, meaning that the sample needs to be heated and cooled repeatedly in order to denature and replicate the DNA or RNA1. Isothermal amplification greatly simplifies this process because various enzymes perform the tasks of denaturation and replication at a constant temperature. For the scientists on the team, understanding that this process could be applied to the diagnostic device was a huge breakthrough.

Having demonstrated a feasible scientific technique to support this project, my mom is now working with a team of engineers to design the actual cartridge for the point–of-care device. The process needs to be very accurate—creating a tool that gives false negatives could be dangerous. The cartridge will be made of plastic and contain microfluidic pumps that control when and how the reagents are combined. A little screen will display results within an hour. In practice, the diagnostic device will be used in the field by minimally trained personnel, not by major hospitals or clinics.

An emerging problem is that medical supplies used in the field receive no refrigeration during transportation, delivery, or storage. The enzymes used for isothermal amplification are living organisms that die at temperatures above 40° C. My mother is in search of an enzyme that can still perform in hotter climates, without refrigeration. Additionally, her team is working to figure out a way to create a dry mixture of all the reagents that can be easily transported over long distances.

My mother's work is a critical piece in a vast web of hi-tech industry, health care, and humanitarian aid. The successes and challenges she faces provide an example of theoretical scientific challenges coupled with the challenges of applied science. It is one thing to build a model, and then another to build it in real life.

Being able to effectively detect HIV/AIDS is a critical step towards slowing the virus' growth and providing treatment. Patients diagnosed with the virus can be treated with antiretroviral drugs, such as AZT, which slow the proliferation of the HIV. Improved diagnostic tools are necessary developments towards curing this epidemic, but they are only a preliminary step. Even though new infection rates are declining globally, approximately 2.5 million people are still diagnosed with HIV annually, 72% of which are adults and children in Sub-Saharan Africa.

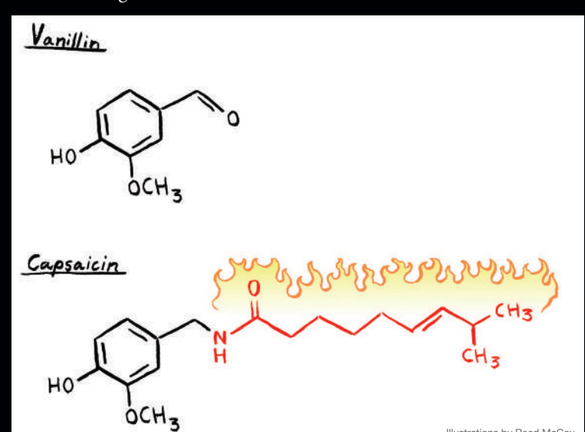
The epidemic must be tackled from many different approaches. Moreover, major steps still need to be taken on national and international levels to improve HIV prevention through increased education, implementation of safer sex practices, and decreasing stigmatization of and prejudice against those afflicted. Furthermore, developing infrastructure in these countries would help provide access to those afflicted in remote regions. Lastly, humanitarian aid remains an essential aspect of giving care to infected and at-risk peoples. To learn more, visit www.unaids.org and www.who.int/hiv.

Sriracha and the Science of **Pain**

By Weelic Chong

Those dining in OSCA will definitely be familiar with Sriracha and its wonderful effects on bland rice, lentils, and quinoa. It's hot, addictive, and painful, all at the same time. Just like good theater, good sauce is made from a blend of different actors. The tanginess of Oberlin's favorite hot sauce comes from vinegar, the aroma comes from a chemical compound called cuminaldehyde, (named after the spice cumin.) and the main player responsible for the burning feeling is capsaicin. Capsaicin belongs to a class of compounds called vanilloids, the most famous of which is vanilla. So how does our tongue tell the difference between vanilla and capsaicin? They taste so different but have similar structures. In this article, we will answer this mystery by following this rule: structure leads to function.

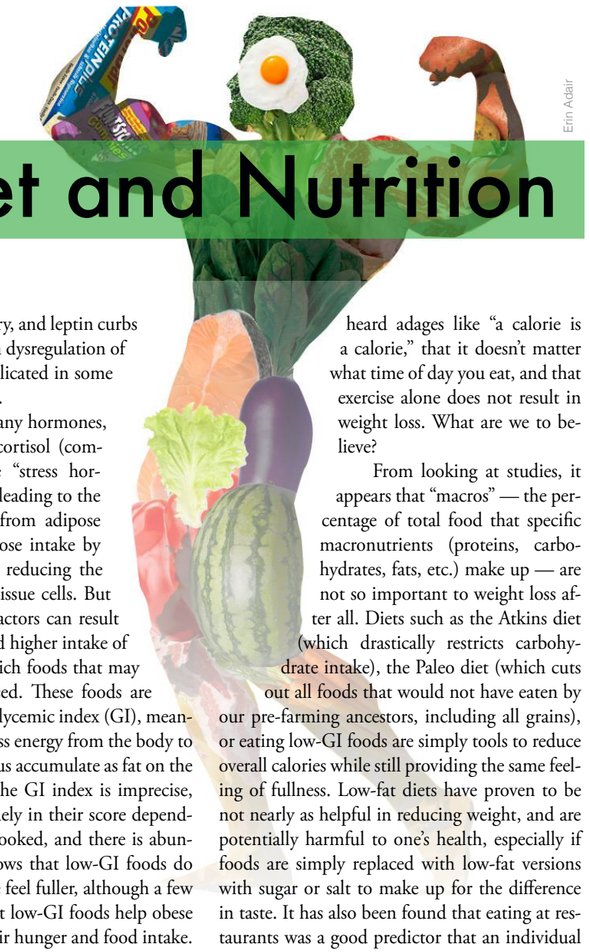
Our tongue is full of taste buds, each of which contains hundreds of receptors cells tuned for tasting things, and we find many different kinds of receptor proteins on membranes of individual cells. What makes capsaicin hot but vanilla not is the long carbon chain that allows capsacin to cross the hydrophobic cell membrane of receptor cells. Capsaicin causes its action by entering the cell and then binding to a receptor called TRPV-1. Vanilla is not spicy at all because the TRPV-1 receptor is only found on the inner side of the membrane, and vanilla is unable to cross the membrane and get to it. When TRPV-1 activates, a nearby neuron sends a signal that the body interprets as pain, similar to what happens when you prick your finger. In this case though, it is not pain that can be alleviated by taking aspirin or painkillers; only by waiting for capsaicin to break its bond with TRPV-1 will you stop getting the heat. If you can't handle it, next time drink some milk before eating spicy foods. The milk coats your tongue with a layer of fat, which dissolves any capsaicin that you later eat, hence lessening the time it stays on your tongue.



Illustrations by Reed McCoy

What makes one chili spicier than another one? To rate chilies, we use the Scoville scale. The amount of capsaicin packed in each chili differs in each variety, with spiciness typically increasing as chilies get smaller. Hotter chili varieties are cultivated every day. Once, I took the atomic wing challenge and it was a searing 2 million on the Scoville scale. For reference, your Sriracha has 2000 units. No wonder my bowels were obliterated. Never again.

However, for those of you into extreme pain, you might want to pay attention to resiniferatoxin. This compound looks very different from capsaicin, but the end result is similar. It also binds to TRPV-1, but it takes 1000 times longer for it to "detach" from the receptor. Resinerferatoxin binds to a different site in TRPV-1. If the tongue is a parking lot, then capsaicin is a bike in a bicycle rack, but resinerferatoxin is the truck that parks itself at the cargo area. In case the suffix "-toxin" didn't clue you in, resiniferatoxin is stronger than any military-grade pepper sprays around. Let me know what cuisines/poisons you can make with them!


Erin Adair

Eat Strong: Diet and Nutrition

By Helen Rich

As 21st century Americans, we have more information about food than we do knowledge about what to do with it. Yet many of us hold conflicting opinions about what is healthy. Especially at Oberlin, in a culture saturated with food politics, it can be hard to decide what to eat, how much to eat, and what foods are actually giving your body the most useful nutrients. For example, many of us say we're "eating healthy" when we are actually dieting to lose weight, and in doing so, we tend to conflate the two. We do this in many ways: cutting out fat from our diets, decreasing carbohydrate intake, limiting calories, etc. In addition, many of us also rely on Body Mass Index, or BMI, as a sort of test of whether we are eating healthily or not. The problem is that BMI and body fat percentages are hardly correct measures of health; there are many extremely healthy people that are, by clinical definition, obese or overweight, and many thin people who eat poorly and are at a higher risk for certain diseases. It is clear that we need to know what foods are actually good for us, and which contribute to health problems.

Most foods comprise compounds called carbohydrates, proteins, and lipids. Carbohydrates are polysaccharides ("many sugars") including anything from sucrose to lactose to cellulose to starch; proteins are strings of amino acids, the "building blocks" of proteins; and fats, a subset of lipids, are molecules with polar heads and nonpolar tails linked together in threes. The body absorbs nutrients made of these compounds through the small intestine and uses them wherever needed (e.g. protein to create new muscle, fats to form new cell membrane, and carbohydrates to store energy).

Fats in moderation are good; they compose adipose tissue which serves as an insulating layer under the skin, forms cell membranes, is crucial in storing the fat-soluble vitamins (A, D, E, and K), and protects our organs. The body needs the energy that is provided through the storage of carbohydrates and fats as adipose tissue. However, it seems that on the whole, Americans consume more food than can be stored by the body as fat. (Interestingly, recent studies have discussed a "good body fat": brown adipose tissue, which converts food energy taken from the bloodstream into heat, to warm the body when it is too cold.) Two hormones are intimately involved in eating: ghrelin makes us hungry, and leptin curbs our hunger. Issues with dysregulation of these hormones is implicated in some instances of overeating.

Exercise affects many hormones, including leptin and cortisol (commonly known as the "stress hormone"), on the whole leading to the release of fatty acids from adipose tissue, decreasing glucose intake by non-muscle cells, and reducing the size of white adipose tissue cells. But economic and social factors can result in a lack of exercise and higher intake of carbohydrate and fat-rich foods that may also be highly processed. These foods are generally high on the glycemic index (GI), meaning that they require less energy from the body to be stored as fat, and thus accumulate as fat on the body. Unfortunately, the GI index is imprecise, as foods can range widely in their score depending on how they are cooked, and there is abundant evidence that shows that low-GI foods do nothing to help people feel fuller, although a few studies have found that low-GI foods help obese individuals control their hunger and food intake. These high-GI foods, generally carbohydrate- or sugar-rich foods, taste great but are generally cut out of the diets of people who are very concerned with nutrition.

"Processed" foods are another demonized category — but what does this moniker really mean? Minimally processed foods usually go through processes like cleaning, drying, freezing, pasteurizing, and packing. Highly processed foods go through anything from milling, hydrogenation, hydrolysis, or enzyme addition to frying, baking, curing, smoking, salting, or the addition of preservatives or coloring. These foods usually contain high levels of sodium, MSG, high fructose corn syrup, or other additives that make food taste better. A study in Brazil found that meals prepared with highly processed foods contain much more sugar, salt, and saturated fat, and much less fiber. Recently, according to an article in the *New York Times*, studies have been published in mass media lauding the Mediterranean diet and eating more food earlier in the day and less food later in the day. Yet we've also heard adages like "a calorie is a calorie," that it doesn't matter what time of day you eat, and that exercise alone does not result in weight loss. What are we to believe?

From looking at studies, it appears that "macros" — the percentage of total food that specific macronutrients (proteins, carbohydrates, fats, etc.) make up — are not so important to weight loss after all. Diets such as the Atkins diet (which drastically restricts carbohydrate intake), the Paleo diet (which cuts out all foods that would not have eaten by our pre-farming ancestors, including all grains), or eating low-GI foods are simply tools to reduce overall calories while still providing the same feeling of fullness. Low-fat diets have proven to be not nearly as helpful in reducing weight, and are potentially harmful to one's health, especially if foods are simply replaced with low-fat versions with sugar or salt to make up for the difference in taste. It has also been found that eating at restaurants was a good predictor that an individual would lose less weight on a diet, perhaps because restaurant food is typically very high in sodium, and is optimized for taste rather than for health.

Common sense seems to say, "Throw out all the unnecessary information about 'superfoods' that will 'slim your belly' and simply pay attention to what you are eating." Processed foods should be avoided, and a low-fat diet should not be emphasized. We should stick to what we have always known: eat lots of vegetables and fruits, and consume enough protein so our bodies have enough fuel. Eating only raw foods can be an easy way to do this; cooking from scratch is another. (Raw food diets are almost entirely plant-based and can include non-pasteurized dairy, but there are many legal issues with this because risks of infection from pathogens are much greater.) This can all be supplemented with healthy exercise at the right level for our own individual fitness. In the end, incorporating a healthier diet comes down to what is easiest to fit in with existing habits, but it is extremely important to know what eating healthily actually means.

Clarissa Fortier

Getting Sprung

Biological Underpinnings of Spring Fever

By Cynthia McKelvey

Before I was a student at Oberlin, the phrase 'Spring Fever' meant little to me. However, once I came to school, the seasons grew more palpable. Perhaps due to the daily hikes around campus, something about the air seemed to penetrate deeper into my skin. I felt especially vulnerable to the mood swings of Ohioan weather. I dealt with winter by resigning to it.

On the auspicious day when the clouds surrendered to sunshine and warmth, I was thrust out of my hibernation by the delicate savor of flowers and fresh grass. The sun filled me with a restless energy that invited me to skip class, sit out on North Quad, and look for four-leaf clovers with a friend. I partied later into the night and struggled to fall asleep as the birds chirped in the early morning. Over time, it became clear to me that many students are stricken with this same 'fever' come spring. A particularly bright-eyed friend became especially reanimated in spring, proclaiming he was 'solar powered'.

Talk to any Obie long enough and eventually you will learn the unique way that the seasonal changes in sunshine and warmth affect them. Their explanations range from the transformation of the monotonous winter grey into bright blue skies, longer days, warmer air, and a pleasant scent of renewal. But is there a more deep-seated biological rationale for such changes in mood and behavior? Is Spring Fever merely a social construct or is it an artifact of evolution?

"I would not be surprised if there was a biological imperative to go out and have fun in the spring," muses Zachary Weil, an assistant professor at the Wexner Medical Center of Ohio State University. Weil, who studies seasonal changes in behavior and physiology in animals, speculates that the drive to get vitamin D from sunlight has something to do with Spring Fever. When the ultraviolet wavelengths in sunlight strike the skin, they stimulate light-reactive chemicals to synthesize vitamin D. The increased production of vitamin D in sunnier months may improve both physical and emotional health.

Overall, the scientific literature on Spring Fever is sparse. Just as it is impossible to appreciate light without darkness, scientists find it useful to study what drags us down in the winter, and to assume that the alleviation of those factors causes us to bounce back in the spring.

Melatonin, affectionately known as the 'hormone of darkness', is associated with seasonal changes in mood, behavior, and health. The pineal gland in the brain modulates the production of melatonin based on light levels. When light enters the eye, it stimulates neurons that connect to hypothalamus, which tells the pineal gland to stop producing melatonin. However, if the pineal gland remained in darkness, it would modulate melatonin cyclically, approximately 10 hours on, 14 hours off. According to Weil, the pineal gland can sometimes 'think' it is in darkness during the day.

"We're not aware of this consciously — because our eyes adjust so quickly — but the lights inside our offices and homes are orders of magnitude dimmer than the lights outside." Sunlight, says Weil, is around 10,000 times brighter than incandescent and fluorescent bulbs. "People in northern climates that might go to work before the sun comes up and leave work after the sun goes down may never be exposed to the level of sunlight that's necessary to turn down our melatonin production." Fathom the brain as an ancient machine responding to archaic devices such as the eyes and ears and it is conceivable that the brain may interpret this situation as perpetual darkness.

Conversely, once the days begin to lengthen and people are exposed to more morning sunlight, the brain produces melatonin for shorter intervals. The difference in melatonin production in the winter versus the spring is the predominant rationale for the prevalence of winter depression, or Seasonal Affective Disorder (SAD) in northern latitudes. Melatonin's effect on mood and behavior is complicated, though. Even though longer periods of melatonin production have been associated with SAD, melatonin can also be used as a treatment for people suffering from winter depression. Experimental therapies have shown that depending on when the dose is given, in conjunction with the patient's natural sleep-wake cycle, melatonin can actually help regulate the circadian rhythm and relieve depression. In general, melatonin production that begins in the evening and stops in the early morning helps most people combat the winter doldrums, which mimics a springtime daylight cycle.

For Obies though, nothing competes with actual sunshine and warm air. Fourth-year Nicole's fondest spring memory happened in the last few days of her first year. Having just pulled three consecutive all-nighters to finish a paper, she shifted her focus to an attractive classmate. "I remember running into him at Stevie, but even inside Stevie it smelled like spring." Emboldened by the triumph of having just completed her freshman year, she decided to catch up with him later that night at a party. "I remember walking back home with him, and I don't know, there was just something in the air."

Things fizzled out between Nicole and her spring fling, but her experience remains an idyllic memory of springtime in Oberlin. "I was totally giddy and euphoric. It was a very spring collegiate freshman year experience." Nicole's experience is one of many similar ones from several students I interviewed about their experiences of springtime in Oberlin. Some ancient vestige of biology springs from the increase in vitamin D, the decrease in melatonin, mixed with end-of-the-year excitement to awaken joy among the students.

What causes a cold? What's going on once our body catches the bug? And why are we college students so terrible about taking care of ourselves when we do get sick?

Shoshana Gordon

The Germ Factory

By Nicole Le

"When I cough, it sounds like I'm exorcising a demon."

Whatever your euphemisms for sickness these days, we can all agree that cold and flu season at Oberlin is nasty business. What causes a cold? What's going on once our body's caught the bug? And why are we college students so terrible about taking care of ourselves (and others, for that matter) when we do get sick?

Colds and flus aren't caused by cold weather — they're caused by germs which spread more easily during cold weather because everyone is staying inside. 'Germ' is a not-so-technical umbrella term that includes bacteria, viruses, fungi, and protozoa. Colds and flus are caused by viruses, non-living entities that rely on host cells (like the ones in our bodies) to reproduce. Viruses come in all shapes and sizes, but cold-causing ones are called Rhinoviruses, while flu-causing ones belong to the more familiar Influenza family. Like all other viruses, they inject their DNA into a host cell and hijack the living cell's reproductive abilities to make more copies of the virus. The viral replication eventually kills the host cell and it breaks open, flooding the body with viruses.

Cold seasons result from environments where germs spread easily, like the high density living conditions of college. Germs become a danger to others as your immune system flushes those foreign invaders out through your nasal passages and throat. Covering your nose and mouth when you sneeze or cough is great for protecting your professor from snot during office hours, but imagine what happens when you put your hand back down on the chair arm, and then six other students come in and sit in the same chair!

Oberlin Student Health Services does what it can to treat students but the onus of prevention falls on the students. College-age students are among the least likely of groups to get the recommended flu vaccines because of the way students tend to seek and process risk information. Inaccurate rumors about vaccines get disseminated via Youtube, Facebook, and Twitter and before you know it, only 13% of students actually get vaccinated against this season's big hitters.

So although hacking that demon out during class might be an option, everyone will thank you for staying home with your cold instead, and nursing it and yourself back to good health.

Fantastic Fungi

Stella Rosen

Earlier in the semester, amidst the usual madness that is the Exco Fair, I ran into Christin Anderson, a 4th year biology major, and was pleasantly surprised to find out that she was teaching a Mycology Exco. Mycology, in case you were wondering, is the scientific study of fungi. So far, the Exco has been a success. We meet once a week, and currently we are working on growing our own oyster mushrooms to eat. I decided to sit down with Chrisitin and find out more about her interest in fungi.

How did you first get interested in mushrooms and fungi?

My parents are national park rangers so I grew up in a family of biologists, so I always have had a good basic understanding of biology. When I was at the library one time, I saw a book called Mushrooms and Toadstools, and it was full of all these really cool [mushroom] pictures. The library ended up letting me keep the book. After that, I started collecting and reading books about mushrooms- I would even ask for them for my birthday. All kids go through phases and this one just stuck!

You once told me "Fungi could save the world." Why should people care about fungi?

I did say that fungi are going to save the world — but I am not actually sure how. It's something that I hope to learn about in the class. Paul Stamets wrote a book called Mycelium Running. He has written a lot about myco-remediation — that's when mycelium are used to clean polluted soil.

What are mycellium?

The mycelium is the fungus, the mushrooms we see above ground are fruiting bodies, analogous to apples on a tree. The mycelium is a microscopic net of thread-like cells. They're basically everywhere — in wood, soil, all over the place. Anyway, in terms of Myco-remediation, [mycelium] can get rid of toxic chemicals from soils. They even degrade petroleum products.

What inspired you to teach Myco Exco?

That's an easy one — the Biology department currently doesn't offer a class. This is frustrating because we're missing out on a whole kingdom! The Exco was extremely popular. I got around 75 applicants, many from the biology department.

What advice would you give to other aspiring Mycologists?

If you're an amateur starting out, you should go out, get a field guide, and try to "key things out." It's the same thing with other natural sciences; learning in the field is the best. You just have to try things out.

There are lots of different topics to study within mycology. Most people study mushroom identification for foraging. But there's also bioremediation, mushroom cultivation, medicine, art. I would tell people interested in studying mushrooms to diversify and get familiar with all of the different aspects of mycology because there are so many!

Can you tell me a little bit about the fungal flora of Northeastern Ohio?

There is a huge diversity of mushrooms in Ohio. There are lots of edibles: Inky Caps, Shaggy Lepiota, giant puffballs, and the orange peel cup. I've heard there are morels but I've never actually seen one. There are also lots of pathogens — fungi that we don't seek out — Dutch elm disease for example. It's a big problem.

Where is the best place to look for mushrooms around Oberlin?

Chance Creek — people should go there more often. The fall is really the best time for mushrooming. The Arb is also a good place.

What is your favorite thing about fungi?

We have much more in common with fungi than most people would think. We're both heterotrophs, meaning that we don't make our own food but get it from our environment, get food from outside. Fungi and animals also share a similar set of proteins. All fungi have cell walls of chitin, which is not found in plants. As well as being heterotrophs, we both store energy in the form of glycogen. And we share most of our ribosomal RNA (80-85%), which contributes to the difficulty humans have in fighting off fungal infection. And we're both fleshy.

What is your favorite mushroom?

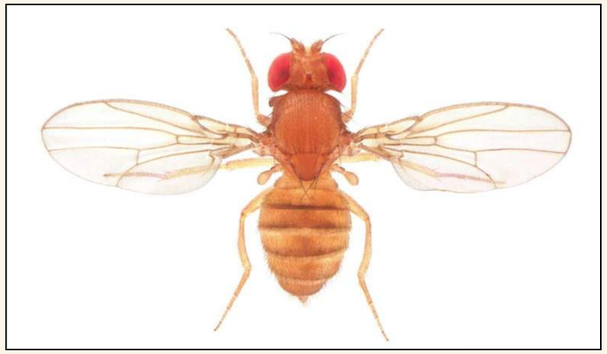
Rhodotus palmatus. It has a veined, kind of wrinkly cap. It sort of looks like a peach.

As a kid I also went through a phase of mushroom fascination. The appeal was in their mystery—where did they come from? Why didn't they have visible roots? I used to take photos of the mushrooms growing in my yard with a disposable camera everyday in hopes that I could create a time-lapse movie like the ones on TV. Unfortunately, this phase faded following a fourth grade Career Day report on being a mycologist, but mushrooms have retained a hold on my imagination. Christin's Exco has illuminated many of the strange qualities of mushrooms and also brought to light some of the potential for the application of mushrooms in solving environmental problems. One of the first things I did upon arriving back to Oberlin was to check a jar of coffee grounds that had been sitting in my closed for two weeks after being inoculated with the mycelium of an Oyster mushroom. Sure enough, some mysterious white specks had appeared in the jar, making visible the hidden world of mushrooms—the network of mycelium that permeate the earth beneath our feet.

Interview by Zoe Lye

Biology's Obsession with *Drosophila melanogaster*

Your Everyday Fruit Fly— Or is it?



By Purba Tyagi

"[Tax] dollars go to projects that have little or nothing to do with the public good — things like fruit fly research in Paris, France. I kid you not." – Sarah Palin

Although scientists often mock Sarah Palin for this quote, it is not immediately clear to many non-scientists why it was such a faux pas. While working with fruit flies, or *Drosophila melangoaster* (the Linnaean name for fruit-flies which translates from Greek to 'dark-bellied dew sipper'), several summers ago, it was hard for me to understand how studying a creature so different from humans in such intense detail could be useful for understanding our biology.

However, fruit flies are one of the most prominent model organisms used in the field of biology right now. Biologists have used them as a model of multicellular organisms for over a hundred years, and the field has only expanded since then. It turns out that *Drosophila* are a vastly important proxy for understanding many of the mechanisms that govern our lives, especially the ones that rely on genetics (which are nearly all of them).

The genetic code found in *Drosophila* is made up of the same DNA as found in humans and almost all other living organisms. Due to this universality of genetic code, principles of heredity, sex-linkage, protein synthesis and transportation can all be studied in the fruit fly and extrapolated in ways that are relevant to human biology.

It is true that other organisms more closely related to humans, mammals like rats, rabbits and chimps, share these characteristics as well. However, fly-research is hugely more cost efficient relative to using other living biological models. Fruit flies are easy and cheap to maintain, reproduce quickly, and produce a great deal of offspring, making them successful genetic model organisms. Additionally, they are large enough to be examined often with the naked eye or which the help of a rudimentary, light-microscope, which can make them easily accessible to scientists.

Thomas Hunt Morgan, a Nobel Prize-winning professor, is credited with being the first to use *Drosophila* in genetic experiments. He and a group of graduate students with magnifying glasses conducted genetic experiments in a dark Columbia University laboratory which came to be known as the first 'fly room.' The results of their work laid the foundation for the science of modern genetics. Mendel's ideas about inheritance had been around for many years, but there was no evidence of a physical mechanism until Morgan's work in the early 1900s. Morgan bred a number of different fly strains together, analyzed the characteristics of their offspring, and was able to form a number of theories which are still accepted today. Additionally, as Morgan began to discover, many of the genes present in *Drosophila* are similar to, or "homologues" of, those found in humans. Indeed, many of these homologues have similar functions in *Drosophila* as they do in humans.

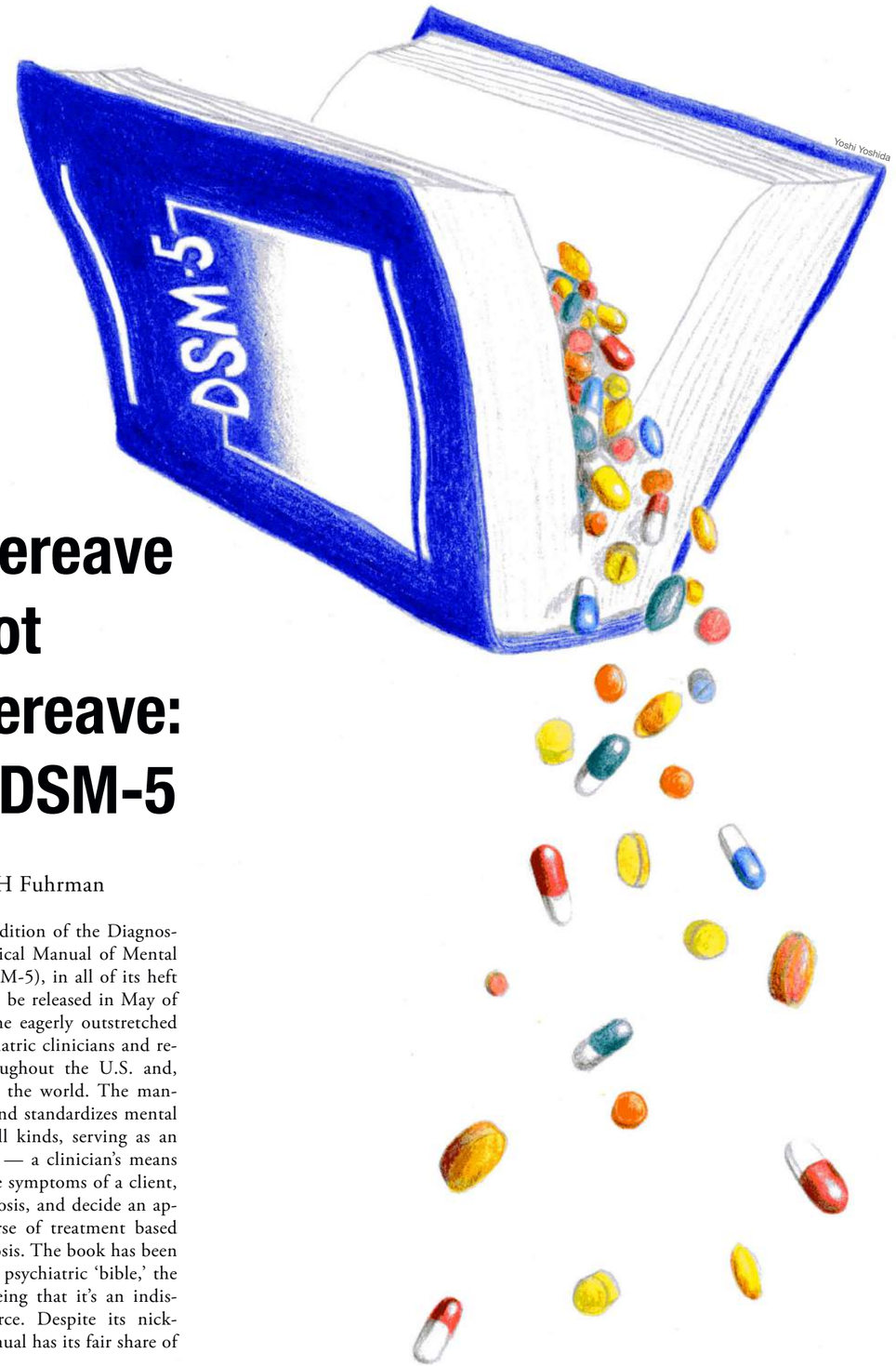
For example, *Drosophila* produce molecules similar to insulin to regulate their blood sugar levels. Loss of this molecules results in elevated blood sugar, a common condition with diabetics. This allows researchers to study the mechanisms of this disease and explore possible treatments all using the flies. The hugely varied research being done in the field is made possible in large part because it's cheap to conduct.

Fly research has been integrated into scientific fields across the spectrum from behavioral neuroscience to biotechnolegy development.

Huge leaps have been made especially in research exploring the fly brain. Taiwanese researchers are half-way through a process that will ultimately yield a complete map of the wiring and connectivity of the fly brain. At the end of this process, no other nervous system will have been explored in such detail as the *Drosophila*'s. Despite the fact that the *Drosophila* brain is quite a lot smaller than that of a human (they have 100,000 neurons on average while we have 100 billion), scientists see this map as the first step to really understanding the complex connectivity in human brains. This project has already revealed commonalities between the nervous system of the fly and the human. The two species have at least six neurotransmitters in common, both have brains which divided into two connected hemispheres, and the basic construction of both nervous systems is organized with local clusters of neurons working in tandem with long-range connections.

Dr. Olaf Sporns, a computational cognitive neuroscientist has found this research to be especially compelling and says that future researchers "may now be able to pinpoint how information flows through the fly brain network to accomplish certain goals." If a complete atlas of each wiring in the fly's brain is created, researchers could test their theories of how information flows through the synapses in the brain via computer models. The primary investigator of this research, Dr. Ann-Chyn Chiang, sees scientists being able to one day use programs to input information into the virtual atlas and receive a virtual output that would essentially mimic the brain's response. Dr. Sporns goes further with this idea saying: "It's not out of the question that if we had a complete cellular map and a good database, that we could create virtual organisms."

And you thought fruit flies were just kitchen pests.



To Bereave or not to Bereave: The DSM-5

By Isaac H H Fuhrman

The 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), in all of its heft and glory, will be released in May of this year to the eagerly outstretched arms of psychiatric clinicians and researchers throughout the U.S. and, more sparsely, the world. The manual classifies and standardizes mental disorders of all kinds, serving as an index of sorts — a clinician's means to evaluate the symptoms of a client, assign a diagnosis, and decide an appropriate course of treatment based on that diagnosis. The book has been christened the psychiatric 'bible,' the implication being that it's an indisputable resource. Despite its nickname, the manual has its fair share of non-believers. This edition, the most recent iteration since 2000 (the DSM-IV-TR is currently in use) marks the fifth revision to the text since its first publication in 1952.

So why update now? What about our understanding of mental disorders has inspired a revamping of the Manual for the first time in thirteen years? The American Psychiatric Association (APA, the professional organization of psychiatrists that publishes the Manual) states on its webpage that the 5th edition is the culmination of "an agenda to expand the scientific basis for psychiatric diagnosis and classification." The idea was first hatched thirteen years ago, and I like to imagine a few 'elite' psychiatrists called a clandestine meeting of the minds to launch the project in the wee hours of the night; research testing the validity of planned disorders has been ongoing ever since. Now, after countless trials, the APA is ready to publish what it considers to be a finished product — an unerring inventory of all known psychiatric disorders.

There is an issue of transparency here, however. The APA has declined to reveal many details of its research, and how exactly those findings translate into added, deleted, and modified conditions included in the Manual. Without access to the DSM-5 work groups' empirical sources, many a critic has prematurely assumed the worst: hasty decisions founded on deficient evidence. Dr. Allen Francis, former chair of the DSM-IV task force, writes, "this is the saddest moment in my 45 year career of studying, practicing, and teaching psychiatry." Francis bemoans much about the new manual, and his largest complaint is perhaps the exclusion of the bereavement clause for the diagnosis of major depressive disorder (MDD). Currently, the clause advises against a diagnosis of MDD for a profoundly grieving and depressed individual within two months after the death of a loved one. The new manual will replace this timeframe with a more immediate one, and recommend a diagnosis after a few weeks of these symptoms, regardless of their origin.

Grieving after the loss of a loved one is seen as a perfectly normal and necessary coping mechanism, one that shouldn't be pathologized and treated with psychotropic medication. (Francis satirically envisions a drug of the future called GrieveAway, designed to counteract the neural workings that produce grief.) The issue raised is one of social treatment — how we view individuals who are labeled with a diagnosis such as MDD, and the dehumanizing stigma attached to it. The diagnosed are likely to incur social and occupational prejudice for a condition that has no place being thrust upon them. For example, in formally requesting a leave of absence from a job, a person with MDD may have to divulge that feelings of depression have significantly impeded his job performance. A diagnosis like MDD, when viewed as intrinsic to a person's character, has the potential to make the already-alienated feel even more so.

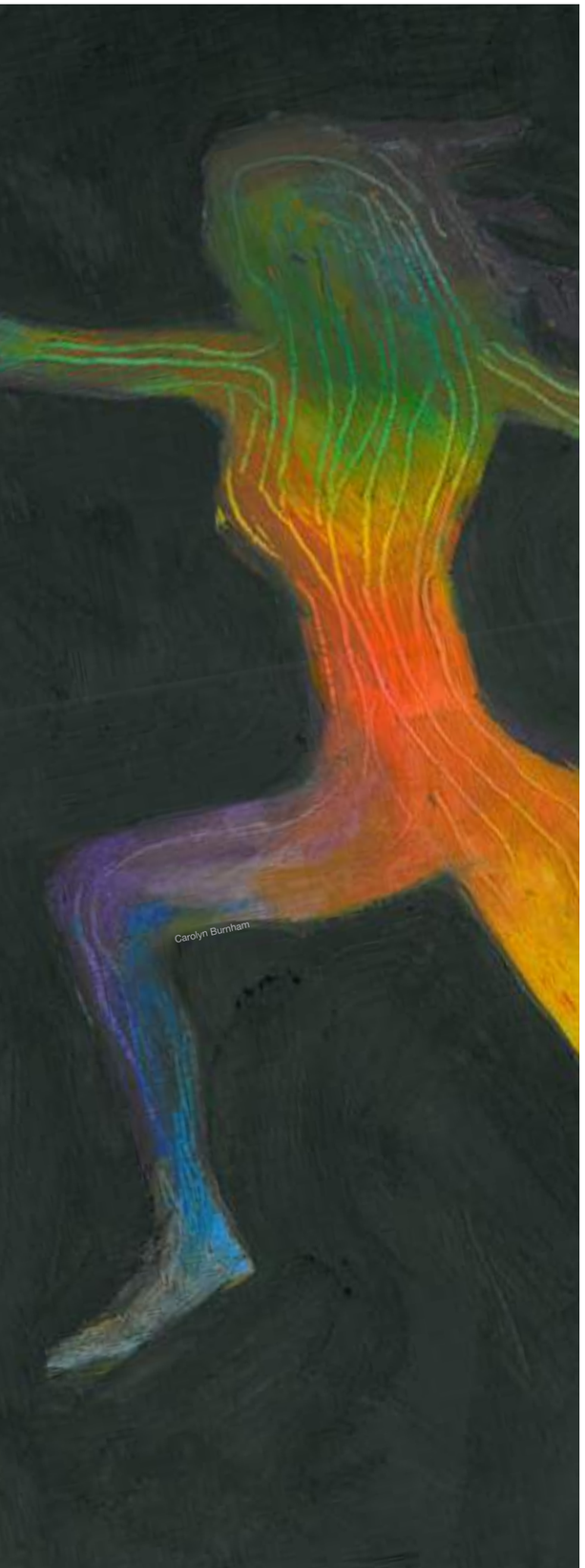
This is a valid concern. Yet it may be useful to keep in mind the first necessary condition for a diagnosis to be made: a (bereaved) individual must approach a clinician in earnest, seeking help in some form of treatment, whether it be mere guidance, talk therapy, or medication to alleviate his suffering. There is no such organization as the psychiatric police who can detect the onset of clinical depression, thunder into a person's home, and issue a diagnosis on the spot. By the same token, a diagnosis is also not ordained by a talking Diagnostic and Statistical Manual; it is a conscientious judgment made by a well-trained clinician. This clinician has the license to use her discretion on a case-by-case basis; she evaluates the severity of an individual's grief, the prognosis for its amelioration, and whether or not the resulting depression poses an immediate threat to the patient's safety. She treats the specifics of the patient and does not look for a set of symptoms to match a definition in the Manual. If these are measures a psychiatrist does not take, she should not be practicing. In such cases, we should be condemning clinicians' inflexible adherence to the guidelines of the DSM, which are not meant to be unconditional regulations. The 'bible' possesses no inherent power without agents to breathe life into its pages.

The exclusion of the bereavement clause in the DSM-5 is considered to be emblematic of our society's general 'overmedicalization' of normal human behavior. The new manual will reduce the threshold for number and severity of symptoms required to make a diagnosis; it will add more novel psychiatric conditions than it will delete irrelevant ones. The proportion of the mentally ill will grow, and that of the mentally normal will shrink. Francis and fellow opponents claim this widening grants psychiatry access where it does not belong, or rather, to people for whom psychiatry is not appropriate: those individuals who experience emotional disruption within the spectrum of 'normal' moodiness. In other words, the DSM-5 will make psychiatric mountains out of everyday emotional molehills.

This is a troublesome thought for many, especially those who consider mental health in black and white distinctions. These folks believe that there exist two groups of people in this world, the mentally healthy and the mentally ill, and that the ill are lesser in some way than the healthy. And many argue that the DSM only augments this absolutist way of thinking. We are all anxious, sad, and neurotic to a certain degree; why should an arbitrary boundary dictate whether or not we're branded with a psychiatric diagnosis? The truth is, a threshold for diagnosis is a necessary precursor to treatment. Without one, there would be no standard practice to identify good candidates for treatment; if a patient consults multiple clinicians, he may receive multiple diagnoses. This has the potential to uproot the patient, who presumably seeks out therapy to gain emotional stability, and without a standardized threshold, ambiguity may breed confusion.

The difference between the DSM's classification of the mentally ill vs. the healthy and the social response to it is that the DSM makes no value judgment of the people implicated within its pages. Ironically, in condemning psychiatric diagnosis, skeptics of the practice—the ones who cry "social construction!" and a lack of objectivity—only furnish the stigma they wish to disband. They accomplish this by implying that mental illness is a source of shame. In their minds, a 'damning' diagnosis—of MDD or otherwise—adversely impacts a person's sense of self-worth. Being labeled as having a mental disorder outweighs the potential benefits of the diagnosis. Yet the treatment in question intends nothing more than to alleviate a patient's problems and improve their quality of life.

These are challenging issues to grapple with. Clearly, there is no single correct way to catalogue the criteria of psychiatric conditions. This is the unfortunate plight of the DSM-5's architects. The creation of the manual represents a Herculean task, one that is bound to precipitate the ire of those who don't agree with its content. But until these critics propose an explicit, alternative solution to the problem of mental disorder classification, I suggest they redirect their criticism away from the DSM itself. Agents who abuse its power — inflexible clinicians, avaricious pharmaceutical companies, and the forces of stigma — these are the true arbiters of negativity that surround psychiatric diagnosis.



The Biology of Running

By Lizzie Roberts

The blistering sun beats down on your head; sweat drips into your eyes and open mouth. The plains of the savannah shimmer, disappearing into the horizon. The antelope is just in sight, a distant speck, maybe a mile or so ahead of you. He's faster than you, but you've been keeping him in your sights and chasing him down for the past four hours. Your breath is regular and easy through your open mouth — you don't need to pant to regulate your body temperature. The speck of the antelope draws nearer and nearer. He's covered in fur and the baking sun is relentless; it's only a matter of time.

Although recreational running has enjoyed a boom in popularity since the '70s, there is still a prevailing belief that running is an inherently self-destructive form of exercise. This is not without foundation — with every impact, a runner's leg is jarred by a force equivalent to approximately three times his body weight. Runners often experience a number of casual injuries, ranging from knee pain and shin splints to stress fractures and inflamed Achilles tendons. Many prefer forms of aerobic exercise that are equally beneficial, but less harsh on the body: biking, swimming, using an elliptical or dancing to Richard Simmons. However, there is increasing evidence to support the theory that the problem is not that we run, but rather the way in which we run.

Running comes as a (reasonably) natural movement to most humans, even to those who don't enjoy it recreationally. When broken down, however, it involves an intricate coordination between the quadriceps, hamstrings, gluteus maximus, Achilles tendon, and iliopsoas, among many other tendons, ligaments, and muscles. The phases of running can be reduced to five components: plantar flexion, hip extension, foot-strike, midstance, and hip flexion. Ligaments such as the plantar fascia support the arch of the foot and store energy when stretched; the abdominal muscles stabilize the spine and help diffuse force throughout the lower back. The nuchal ligament at the back of the neck prevents the head from bobbing around — incidentally, it's a ligament that many non-running animals, such as pigs and chimpanzees, lack.

If these are the physical mechanisms that allow us to run, what are some of the physical effects that result from consistent endurance running? For starters, the muscles in your legs known as 'slow-twitch' muscles become up to 25% larger. Slow-twitch muscles comprise the classically red type of muscle tissue that utilizes fats or carbohydrates as fuel for aerobic activity; they contract over longer durations of time, but with less force than fast-twitch muscle fibers. They can work for a long time without fatigue, which is why they're useful for sports that require endurance. Fast-twitch muscles are useful for sprinting: they're stronger but consume lots of energy and tire quickly. Secondly, your muscles become better at storing glycogen, enabling them to feed off of a constant supply of energy throughout the run. Thirdly, intermittent stress on bones causes them to calcify and strengthen — continuous or complete absence of stress can lead to thin, weak bones. The number of capillaries threading through these slow twitch muscles increases enormously; the fibers require a constant supply of oxygen and nutrients, and need to be stripped of waste products. Additionally, your cardiovascular system becomes much more efficient as the strain on your heart forces it to strengthen. Resting heartbeats in distance runners can drop as low as 30-40 beats per minute. Specifically, it is the left ventricle that becomes significantly larger in order to pump and distribute an adequate blood supply to the rest of the body. The body also becomes more efficient at utilizing oxygen. "VO2max" is a measurement of your oxygen consumption levels at the most intensive level of exercise, and it increases as your system becomes acclimated to endurance sports and more efficiently absorbs the oxygen in your lungs. Finally, regular aerobic exercise is thought to encourage hippocampal neurogenesis in humans, which may help combat some of the cognitive deficits that oftentimes accompany aging and the withering of hippocampal neurons.

But what about the physical changes that occur in the brain? The myth of 'runner's high' has long been labeled as biologically suspect. However, advances in neuroimaging technology have revealed a potential physiological explanation for the phenomenon.

A recent study was able to confirm that a flood of endorphins is released in the brain during intense aerobic exercise. Endorphins are endogenous opiate proteins heavily associated with mood changes. They resemble heroin insofar as they can produce extraordinary feelings of euphoria and well-being; both the sensations of pain and orgasm trigger their release. In 2004, German researcher Dr. Henning Boecker of the University of Bonn devised a means to observe whether or not endorphins were being released during exercise. His lab examined the brains of ten runners before and after two hours of running, none of whom knew what they were being tested for. Endorphins were not only detected in the brains of all ten participants, but were also observed to be flocking to the prefrontal and limbic areas, regions associated very heavily with emotion. These areas, according to Dr. Boecker, are activated during romantic love affairs, or when a person hears a piece of music that gives them a chill of euphoria. As a clincher, a positive correlation was observed between the quantity of endorphins detected in the brain and the intensity of the post-run euphoria reported by the runner. Dr. Boecker's lab also conducted studies on the effects of running on pain perception, and found that runners required higher levels of pain stimulation before conceding that something hurt. It's unfair to let endorphins take all the credit for this rush, however — endocannabinoids, chemicals produced in the brain that bind to the same receptors as the THC in marijuana, are also thought to contribute a great deal to the psychological effects of running.

Though running has a number of physical and psychological benefits, it also believed to have a number of pitfalls. One of the more pervasive myths about running is that it can lead to permanent knee damage and early onset arthritis. However, several studies indicate that running 30-60 minutes five or six days per week actually encourages the joint to heal and strengthen by creating micro-tears in the cartilage. A 2011 systematic review looked at 28 peer-reviewed studies on the effects of physical activity on osteoarthritis in the knee joint. They found that physical activity was correlated with an increase in cartilage volume and a decrease in cartilage defects, suggesting that it is actually beneficial for the joint. A long-term study of 1200 people conducted in Framingham, Massachusetts found no correlation between physical activity and increased risk for osteoarthritis.

Another health concern is that regular long distance running may lead to scar tissue in the heart. If the muscle is stretched excessively and not allotted proper healing time, the ensuing scar tissue may eventually lead to stiffening or thickening of portions of the heart. This fibrosis can result in heart failure. While the risk isn't severe for people who run a few marathons in their lifetime, older individuals who have spent their entire lives training were observed to have an unusually high amount of scarred heart tissue as compared to young athletes and age-matched controls. There is not enough data to definitively support the conclusion that strenuous exercise can lead to permanent heart damage, but there's certainly enough to warrant caution to not over-train the body.

Besides long-term accumulative damage, there are an enormous amount of injuries that afflict all levels of runner from casual jogger to ultra-marathoner. Shin splints, stress fractures, runner's knee, plantar fasciitis, lower back pain, hip injury, Achilles tendinitis, hamstring injury, iliotibial band syndrome, and ankle sprains are just a few of the more common injuries. The 'right way to run' fad is more influential now than ever before; thousands of books and articles claim to have the one method you've been missing to keep your plantar fascia strong and your kneecaps from inflaming. One of the more popular theories is the 'barefoot running' method.

The theory behind barefoot running is that wearing shoes makes the runner numb to the pain that normally accompanies improper foot striking — namely, heel striking. A runner without shoes is unlikely to come down hard on the heel bone because it's too painful without cushioning; instead, they'll land lightly on the forefoot, resulting in a less jarring impact shock. A recent Harvard study examined in detail the differences in impact force distribution between forefoot striking and heel striking. Landing on the heel was compared to dropping a rod straight down on its end: a sudden, jarring collision in which all the momentum of the runner is abruptly converted into a single, sharp force distributed up the leg. Landing on the forefoot, on the other hand, was compared to dropping a rod on the ground at an angle: one part of the rod is abruptly stopped, but the impact force is significantly less because the other section of the rod continues to topple over. The forefoot hits the ground and generates some force, but the rolling motion that ensues from toe to heel distributes that force over a longer period of time. The downward force of the runner is converted into rotational momentum.

The scientific evidence as to whether barefoot running actually reduces risk of injury is still inconclusive. The biggest problem with the conversion is that most of us have spent our entire lives strapped into Nikes. Just kicking off the sneakers and expecting to have perfect barefoot form is not only unrealistic, but dangerous. Applying force to muscles and bones that are not acclimated to use without the cushioning provided by a sneaker can lead to increased risk for stress fracture, as the high-frequency forces generated by heel striking tend to distribute through bone. Even if the runner does get a feel for forefoot striking, they can be at increased risk for muscle strain or tendinitis, since the low-frequency impact force generated by landing on the forefoot tends to distribute through soft tissue and muscle. Additionally, runners transitioning to the barefoot method have been demonstrated to accumulate greater bone damage in their feet.

Is barefoot running worth a shot? If you find yourself moving just fine in your cushioned Adidas, a transition to barefoot running may not be beneficial. However, if you find yourself with lower back pain, or frequent joint pain that feels like it may be the result of landing with too much of a jolt, barefoot running may help you learn to hit the ground more comfortably. Just make sure to transition very slowly, starting out with one barefoot mile at the end of your run and adding another every week or two. The body takes time to retrain, and barefoot running will put a different kind of strain on your muscles and tendons. Additionally, make an effort to run with proper form — shoe brand aside, bad form will inevitably lead to injury. A straight back and slight forward lean is what coaches generally recommend; think of your feet as pawing the ground while you run, landing lightly and pushing you forward rather than up and down like a jackhammer.

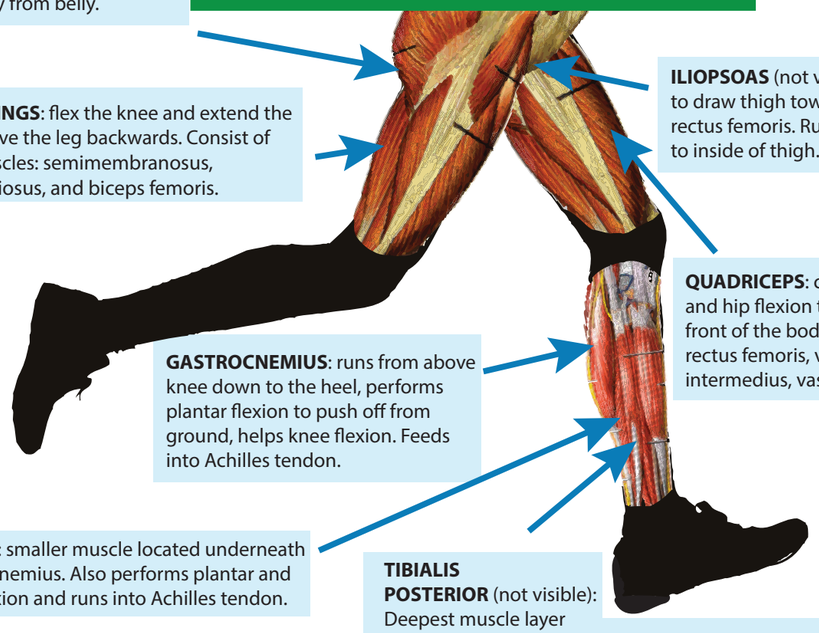
The act of running has deep roots in our evolutionary history. We are equipped with the physiological mechanisms to make us some of the best endurance runners on the planet. Additionally, there are whole hosts of physiological mechanisms that make running a rewarding experience for us. Not everyone enjoys the activity; many people would rather have a root canal than run a marathon. However, the argument that running is too physically detrimental to be worth the benefits is one that doesn't hold water. Adjusting technique can help reduce the risk and severity of injury, as can making sure not to over-train or take on too much too quickly. One day, you may even be able to take down that distant speck of an antelope.

THE PHYSIOLOGY OF RUNNING

GLUTEUS MAXIMUS: performs hip extension, pulling thigh back away from belly.

HAMSTRINGS: flex the knee and extend the hip to move the leg backwards. Consist of three muscles: semimembranosus, semitendiosus, and biceps femoris.

ILIOPSOAS (not visible): perform hip flexion to draw thigh towards belly, aided by rectus femoris. Run from front of pelvis to inside of thigh.



QUADRICEPS: crucial to knee extension and hip flexion to pull the leg up and in front of the body. Consist of four muscles: rectus femoris, vastus lateralis, vastus intermedius, vastus medialis.

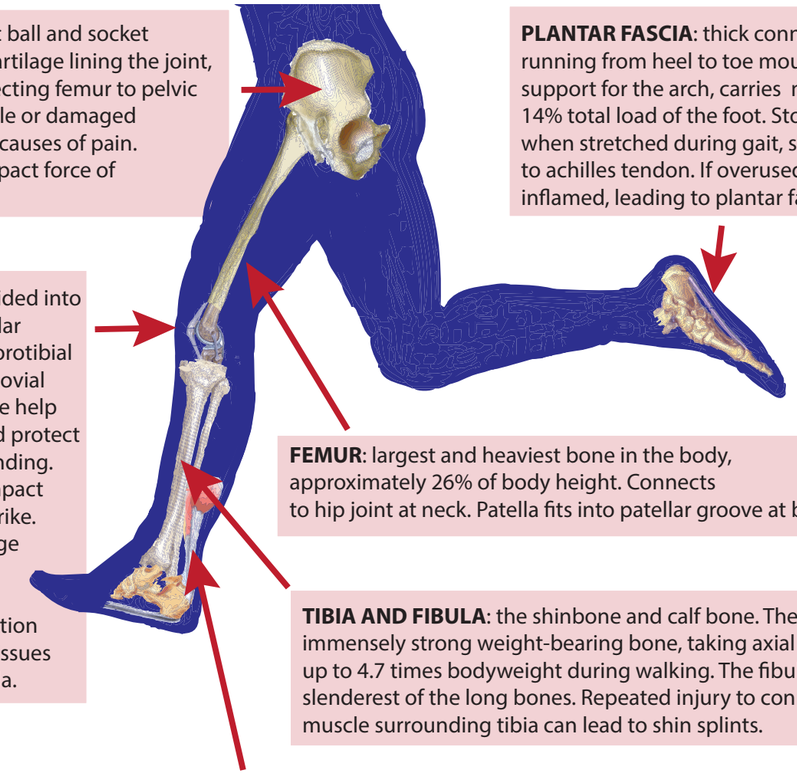
GASTROCNEMIUS: runs from above knee down to the heel, performs plantar flexion to push off from ground, helps knee flexion. Feeds into Achilles tendon.

SOLEUS: smaller muscle located underneath gastrocenemius. Also performs plantar and knee flexion and runs into Achilles tendon.

TIBIALIS POSTERIOR (not visible): Deepest muscle layer in calf, assists in plantar flexion. Located between tibia and fibula.

HIP JOINT: basic ball and socket configuration, cartilage lining the joint, ligaments connecting femur to pelvic bone. Torn muscle or damaged cartilage can be causes of pain. Helps absorb impact force of footstrike.

PLANTAR FASCIA: thick connective tissue running from heel to toe mound, provides support for the arch, carries much as 14% total load of the foot. Stores energy when stretched during gait, similarly to achilles tendon. If overused can become inflamed, leading to plantar fasciitis.



KNEE JOINT: divided into the patella, patellar groove, and femorotibial articulations. Synovial fluid and cartilage help absorb shock and protect against bone grinding. Takes brunt of impact force from footstrike. Damaged cartilage can result in runner's knee, painful inflammation of tendons and tissues behind the patella.

FEMUR: largest and heaviest bone in the body, approximately 26% of body height. Connects to hip joint at neck. Patella fits into patellar groove at base.

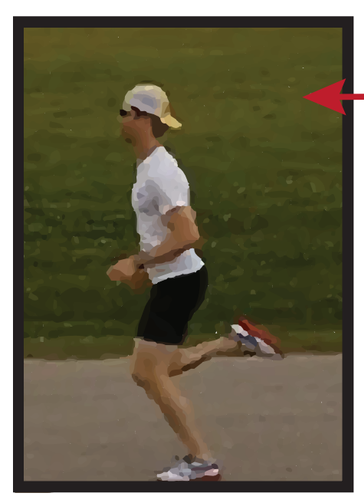
TIBIA AND FIBULA: the shinbone and calf bone. The tibia is an immensely strong weight-bearing bone, taking axial force up to 4.7 times bodyweight during walking. The fibula is the slenderest of the long bones. Repeated injury to connective muscle surrounding tibia can lead to shin splints.

ACHILLES TENDON: connects lower calf muscles to heel bone, allows muscles to lift heel and point toe during plantar flexion. Also stores energy when stretched, like a rubber band—increases top running speed by >80% and reduces running cost by >75%. Can become painfully inflamed due to overuse.

1. **PLANTAR FLEXION**: lower calf muscles contract, driving toes downwards to push body off from foot. Hamstrings flex the knee of grounded leg to drive the body forward.

2. **HIP EXTENSION**: gluteus maximus pulls the newly airborne leg up and backwards, away from the belly.

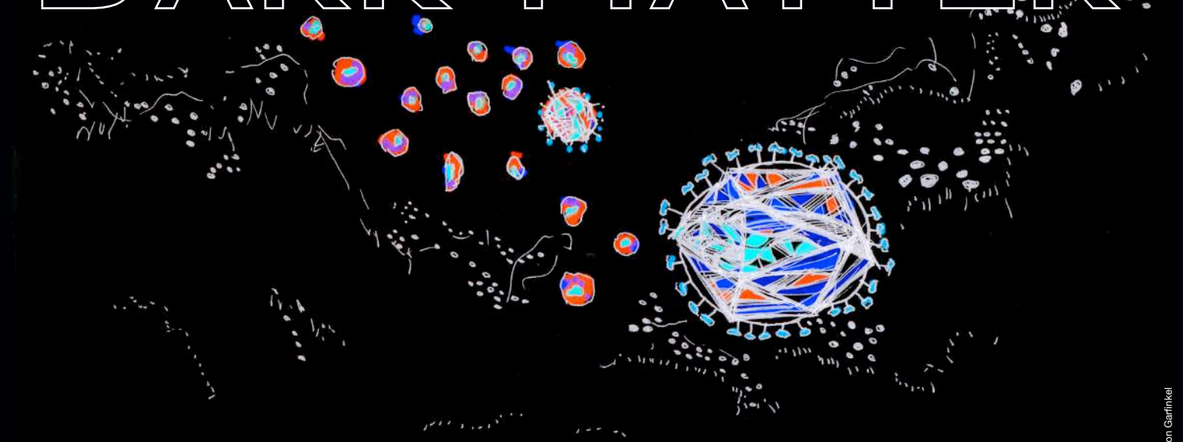
3. **FOOTSTRIKE**: Quads brace for impact. Foot strikes the ground at forefoot, midfoot, or heel. Knee absorbs majority of impact.



4. **MIDSTANCE**: with one foot planted on the ground, gluteus maximus and hamstrings perform hip extension and drag the leg back away from the belly. Knee joint of grounded leg begins to undergo extension. Weight shifts forward over grounded leg and plantar flexion begins again.

5. **HIP FLEXION**: iliopsoas contract and flex the hip to move the airborne thigh forwards and upwards towards the belly, with help from the rectus femoris quad muscle. Other three quads contract to straighten the knee.

Dark Matter



Aaron Gartinkel

By Rachel Budker

Cold, dark, and mysterious. Strange. Misunderstood. No, not your angsty teenage self, but Dark Matter.

You may have heard of dark matter, but what *is* it?

In the 1930s, an astronomer by the name of Zwicky first mentioned 'dark matter' while measuring the speed of galaxy clusters. He, and many after him, noticed big discrepancies between the observed speeds of galaxies within galaxy clusters and what is expected from the observed mass distribution in the cluster. Basically, the calculated mass of the galaxy cluster was not adding up. Something, something quite massive, remained unaccounted for.

Scientists noticed a similar discrepancy on a much smaller scale: within individual galaxies. Scientists can predict how quickly stars should revolve around the center of a galaxy by calculating how much gravitational pull should affect the speed at which the star travels. When scientists calculate and then measure the speeds of the objects, assuming certain masses of the objects that exert gravitational pull on them, the observed speed grossly mismatches the calculations. The difference between the calculated and observed is a huge discrepancy, not just a small anomaly — something enormous is somehow being overlooked.

Dark matter has become the most widely supported theory to explain these discrepancies. Dark matter cannot be seen, does not emit energy, and only interacts with ordinary matter through gravity and possibly the weak force; therefore, its existence may only be inferred from the gravitational pull dark matter has on observed matter, calculated by use of classical mechanics. The Hubble Space Telescope may provide the best evidence for dark matter, allowing astronomers to observe dark matter rings emanating from the collisions of galaxy clusters, indicating the gravitational role dark matter may play in holding galaxies together.

However, much remains shrouded in mystery. Dark matter does not fully account for the unknown substances of our universe. By most recent estimations, 4.9 % of the universe is observable matter such as stars, galaxies, and dust, but only 27 % is dark matter — 68% is currently believed to be 'dark energy'. Dark energy is an even more enigmatic concept than dark matter. Put most simply, dark energy helps account for the majority of the unknown makeup of our universe and helps explain the observed acceleration of the expansion of the universe. Dark energy pushes the universe apart, while dark matter holds it together.

As the dark matter theory grows in support, a greater mystery remains: what is dark matter actually made out of? Many believe that the elemental particles of dark matter have yet to be uncovered, such as the theoretical weakly interacting massive particles (WIMPs); weakly interacting subatomic particles that have already been discovered, such as neutrinos, are not massive enough to constitute dark matter. Terrestrial experiments, such as those underway in the Large Hadron Collider (LHC) in Geneva, have already begun to shed some light on the darkness, and in time will hopefully explain much more about the particles that make up our universe.

A deeper understanding of dark matter will lead to a greater understanding of our infinitely complex universe. However, it is important to note that despite its popular support, dark matter is still a theory. Other theories, such as the antigravity theory, suggest that Newtonian/Einsteinian laws of gravity are incomplete and need to be expanded or rewritten in order to explain galactic phenomena. The discrepancies observed in galactic rotation curves do not suggest an invisible, unaccounted-for mass, but a colossal gap in our understanding of classical mechanics and the laws of gravity at such large scales. Such theories are more complex, stranger, and less favored — yet still absolutely possible.

At the frontier of physics, astronomy, and cosmology, dark matter is just one example of the way scientists continually use creativity and imagination to dream up what the universe may look like, open their eyes, and see if the order of their imagination holds true against scientific data.

Chiropracty:

Medicine or Mysticism?

Reed McCoy

By Connor McCleskey

Chiropracticty, a complementary alternative form of medicine that emphasizes the manipulation of the spine to treat various disorders, has been surrounded with controversy since its creation in 1895 by D.D. Palmer. From its inception as a fringe pseudo-religious movement described as a dangerous, "unscientific cult" by the American Medical Association, chiropractic has grown into the largest branch of alternative medicine in the United States, where $3 billion is spent annually on chiropractic treatment. Today, surveys estimate that 6%-12% of the American population regularly visits chiropractic doctors, primarily for the treatment of lower back pain. With their tendency towards secrecy concerning the details of their practice, a historical distrust of mainstream scientific ideas such as fluoridation and vaccination, and levels of fraud up to nine times higher than medical doctors (by some estimates), chiropractors are often the subject of suspicion and mistrust. Fortunately for the profession, recent studies have demonstrated that spinal manipulation can be just as effective at treating lower back pain as medical treatment. Certain chiropractic ideas are now gaining increased acceptance by the medical community.

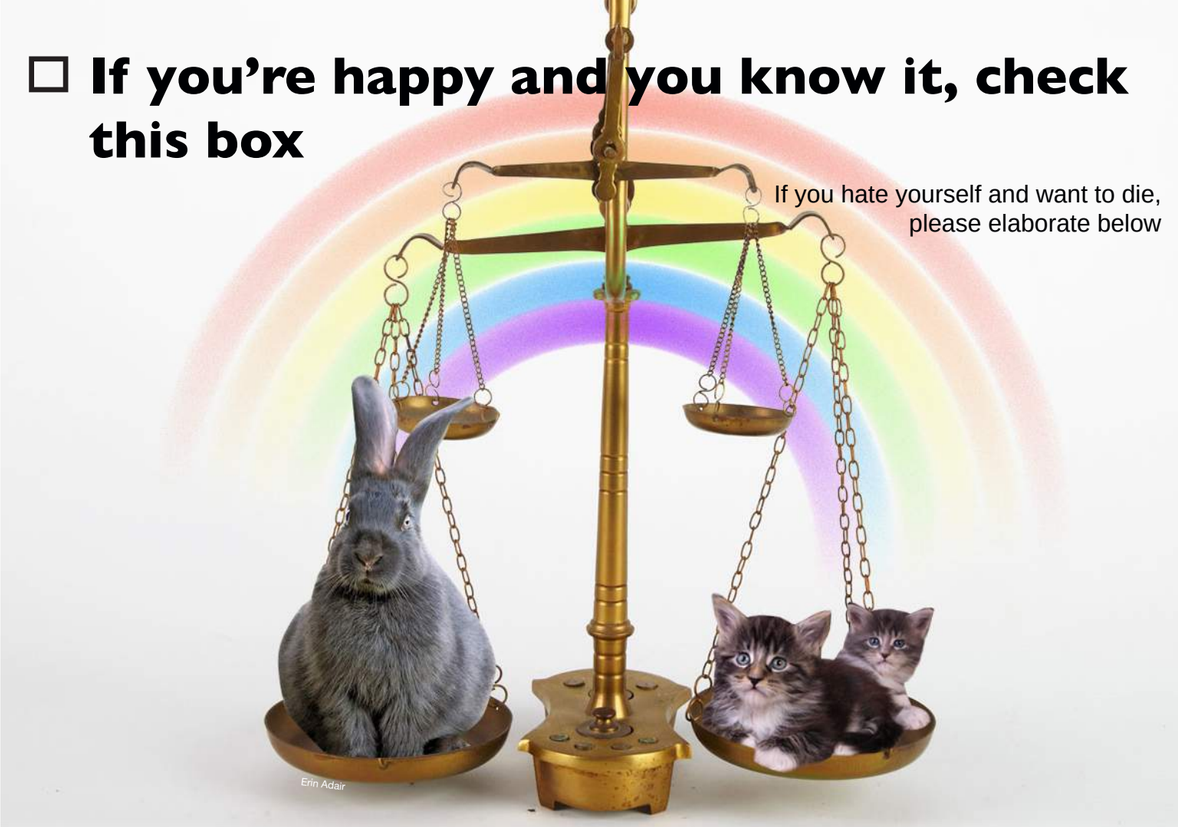
Though most chiropractors share a common holistic perspective on healthcare and disdain for conventional modern medicines and surgeries, modern chiropractic is split into two very distinct camps, colloquially known as the "straights" and the "mixers." The definition has changed slightly over the years, but straight chiropractors basically advocate a purist adherence to Palmer's original ideas, maintaining that vertebral subluxations—misalignments in the spinal column—are the root of almost all human disease. The name itself stems from Palmer's exhortation to practice "chiropractic, straight and undiluted." Historically, the incorporation of metaphysical explanations for treatment has led to criticism from both the less radical chiropractic community and many physicians, who regard it as pseudo-science. In contrast, mixers, who make up the majority of the profession, combine osteopathic, medical, and chiropractic approaches to treatment, often using nutrition, physical therapy and exercise in their practice.

Straight chiropractic is based around the idea of the body's "innate intelligence" (similar to the idea of its "life force" or "Qi" in Chinese traditional medicine) that is responsible for maintaining and healing the body. Chiropractors believe that vertebral subluxations, when they infringe on nerves in the spine and neck, interfere with the body's natural ability to heal itself and maintain homeostasis. Straight practitioners advocate non-therapeutic care; they do not treat specific conditions, instead focusing on enhancing the function of the body and improving wellness, an approach they refer to as "vitalistic". Dr. Ralph Davis, a practicing chiropractor and Dean of the School of Chiropractic at Life University, the largest school in the Chiropractic profession, defines a straight chiropractor as someone who "analyzes the spine to find out if any misaligned vertebra are interfering with the function of the nervous system, and repositions it to allow the body to express its own inner potentials for health to its optimum." Chiropractors serve to reposition these subluxations through a process called spinal manipulation, which consists of high velocity, low amplitude thrusts to vertebra at all sections of the spine. Straight chiropractors therefore do not consider themselves to be practicing medicine, as they believe that the body can recover from all diseases if the spine is properly aligned. This devotion to the idea of vertebral subluxation is one of the primary objections to chiropractic by the medical community. In fact, D.D. Palmer rejected the notion that germs are the cause of illness, stating, "ninety-five percent of all diseases are caused by displaced vertebrae."

A number of different reviews and meta-analyses of chiropractic care in relation to neck and back pain have been conducted, and most have found that the practice has mixed results, though conventional medicine oftentimes fares no better. A Cochrane systematic review of 12 studies including 2887 subjects determined that, though combined chiropractic care provides short to medium-term relief of lower back pain (LBP), "there is currently no evidence that supports or refutes that these interventions provide a clinically meaningful difference for pain or disability in people with LBP when compared to other interventions." For neck pain, spinal manipulation was generally found to be ineffective, though one study did find that it could be useful when combined with standard medical treatment. In a separate study in the New England Journal of Medicine, researchers assigned patients with lower back pain to treatment from a chiropractor, physical therapy, or to a control group where they were provided with a pamphlet and were responsible for their own care. They found that, though chiropractic was about as effective and expensive as conventional physical therapy, neither treatment was found to be significantly more effective than no professional intervention at all. As someone who had to battle with back injuries since the age of 14, I can attest to the limited relief provided by most treatments, chiropractic or otherwise.

The most common accusation leveled at chiropractic is that its treatments do not hold up under scientific inquiry. However, this is not a problem for many chiropractors, who simply don't subscribe to the scientific method; they are supremely confident in their ability to help heal the human body based off their own anecdotal and empirical information. Though chiropractic care may not necessarily cure specific conditions, most chiropractors see themselves as promoting wellness on an ongoing basis, in contrast to the medical approach of treating only symptoms. Dr. Davis sees the profession as "functioning similar to a family doctor providing regular checkups", in that a chiropractor's purpose is to "regularly adjust the spine and offer nutritional and lifestyle advice so that the body can fight off disease by itself." Though more research is needed into the efficacy and long-term impact of spinal adjustment, and chiropractic as a field remains controversial to many in the medical establishment, perhaps the two schools of thought can one day integrate to form a comprehensive model of care.

☐ If you're happy and you know it, check this box



By Samsun Knight

Lower your expectations now. You'll find yourself much more satisfied by the end.

Have you heard that money buys happiness? That's right, your parents lied to you again. In a recent global survey, researchers demonstrated that wealth is a key variable that can explain the disparity of happiness between countries. And we know that it's really true, because science tells us so.

Happiness research first emerged as an officially 'sponsored' discipline in 1972, when the 16-year-old King of Bhutan, Jigme Singye Wangchuck introduced Gross National Happiness to his country as an alternative measurement of societal well-being to Gross Domestic Product. This development was met with a resounding global silence; no one cared, and the metric was widely derided, or at best, ignored. Bhutan used these findings as the rationale to cut down on deforesting and mandate that tourists spend at least $200 USD during their visits. However, since then—especially after research methodology grew more standardized in the nineties—happiness research has taken hold. Many economists now eagerly quantify all the fun they're missing out on, while more and more governments are surveying their citizens' 'well-being' or 'life satisfaction'. Even the mother country, Britain herself, has tasked its Office of National Statistics to a 4 year, $3.2 million research project on the subject, dubbed a "national wellbeing campaign" by the Wall Street Journal. Now that happiness research has been embraced by both economists and her majesty the Queen, few readers will need further proof that this discipline is seriously suspect. But in case you're still credulous, here's why you're wrong.

Questions

"Taken together, how would you say that things are these days?"

"Do you think of yourself as very happy, pretty happy or not too happy?"

"Have you been feeling reasonably happy, all things considered?"

The above are questions taken from various happiness surveys. Based on answers to similar questions, researchers have determined the following: giving away money makes people happier than spending it on themselves; eating chocolate sparingly makes us appreciate chocolate more; and while people expect that 'life satisfaction' will double if they make $55,000 per annum versus $25,000— in fact, they are only 9% more satisfied when such a change in fortune occurs. But how do we know this? And what does "9% more satisfied" actually mean?

The Findings

The reliability of its foundation aside, happiness research is relaying some pretty interesting trends. Here are some favorite 'facts' from happiness research so far:

- *Money Matters*. According to Gallup global polls, there is a direct causal relationship between wealth and self-reported well being across countries.
- *Exercise Doesn't*. Based on studies of twins and families, Dutch researchers have established that there is no causal effect between happiness and physical activity. But they are Dutch, after all.
- *Forced Affirmation Hurts*. Individuals with low self-esteem feel even less confident after they attempt to affirm themselves and (apparently) fail. This accompanies a recent trend in therapy, which advises patients to accept "negative self-talk" on the grounds that faking it till you make it doesn't work when the person you're trying to fool (yourself) knows it's fake.
- *Living in the Moment Helps*. Daydreaming is associated with dissatisfaction—unhappy activities are associated with wandering minds, and often, such minds wander into an unhappy place.
- *$75,000 a year is the perfect income for an American*. Below that, happiness levels drop steadily, but above that margin, the returns quickly fall off.
- *The Pursuit of Happiness Makes You Sad*. The single-minded search for happiness makes us unhappy. Research from one study shows that "[those] primed to value happiness became less (not more) appreciative of positive events in their immediate environment"

Questions About Questions

Problems abound in these surveys, but the most notable are issues of subjectivity and context.

Subjectivity

Imagine how Ee-or from "Winnie the Pooh" might answer the questions above. Would you expect his answers to bear a correlation to his external environment, or would they (almost entirely) be determined by the fact the Ee-or is kind of a downer?

Now imagine that the Queen from Snow White was asked the same question, after she learns that Snow White has been vanquished. She would probably report that she's SO HAPPY. Do you believe her? And if so, do you think that her version of happiness should be recognized as consummate with Piglet's?

Subjectivity is the fundamental problem with basing scientific studies on questions like, "Taken together, how would you say things are these days?" Maybe people who exercise are just more moderate when they assess their own happiness. Perhaps when people make $55,000 a year, up from $25,000 a year, they are in fact twice as happy as they might have previously defined it, but they're also 95.5% more jaded, so they only report a 9% increase. (And again, does anyone know what a 9% increase in happiness feels like?) Subjective variables such as these undermine the validity of the data as an estimate of aggregate wellbeing. Furthermore, they especially undermine the resulting comparisons of happiness across nations—what if everyone in Switzerland is really mean, like the Queen, but society allows them to be mean, so they're all just fantastically pleased with themselves? Or, maybe everyone in Ireland is like Ee-or when they're sober, which is the only time when they're surveyed, but find fulfillment as soon as they're drunk? Or if researchers stumble across a Winnie-the-Pooh-with-perpetual-honey society that finds happiness so unexceptional they don't even bother to report their satisfaction on surveys?

Context

Imagine how happy most G.I.'s were to return home from World War II and find that they could attend college. Imagine how happy 16th century folk were to have plumbing. Now compare that to the contentment of a typical college student today. Researchers tend to overlook that happiness and satisfaction are based on standards that we frequently borrow from culture and society, which evolve over time. In fact, they can often change upon a simple shift from one subculture to the next. Just watch an episode of "Gossip Girl" after viewing "Annie the Orphan" to see what I mean.

This problem is compounded by the tendency for many happiness surveys, such as the Gallup World Poll, to employ a ladder analogy. They ask their respondents to imagine a ladder in which every subsequent rung represents a successively better life, and decide which "rung" corresponds to their current life. Maybe money determines happiness across countries, or maybe American culture is so pervasive that people across the globe judge themselves in comparison to the Hollywood dream.

While problems with context challenge the validity of the research, it especially makes comparing happiness over time—like when the Gallup World Poll declared that Americans in 2012 were the happiest since 2008—inherently flawed. Maybe our standards have just dropped. Who's to say?

So Just What Are We Asking, Anyway?

Aside from these superficial problems, there is one profound assumption underlying the vast majority of current happiness literature that is even greater cause for concern: the preference of hedonic happiness over eudaimonic happiness. Eudaimonic happiness comes from Aristotle's notion that "true happiness is found by leading a virtuous life and doing what is worth doing, with the realisation of our human potential as the ultimate goal." In so many words, a meaningful life. As a goal for society, hedonic happiness is a more recent construction, often attributed to Jeremy Bentham and the utilitarians. This is the "fun" associated with such things as roller coaster rides and, well, sex.

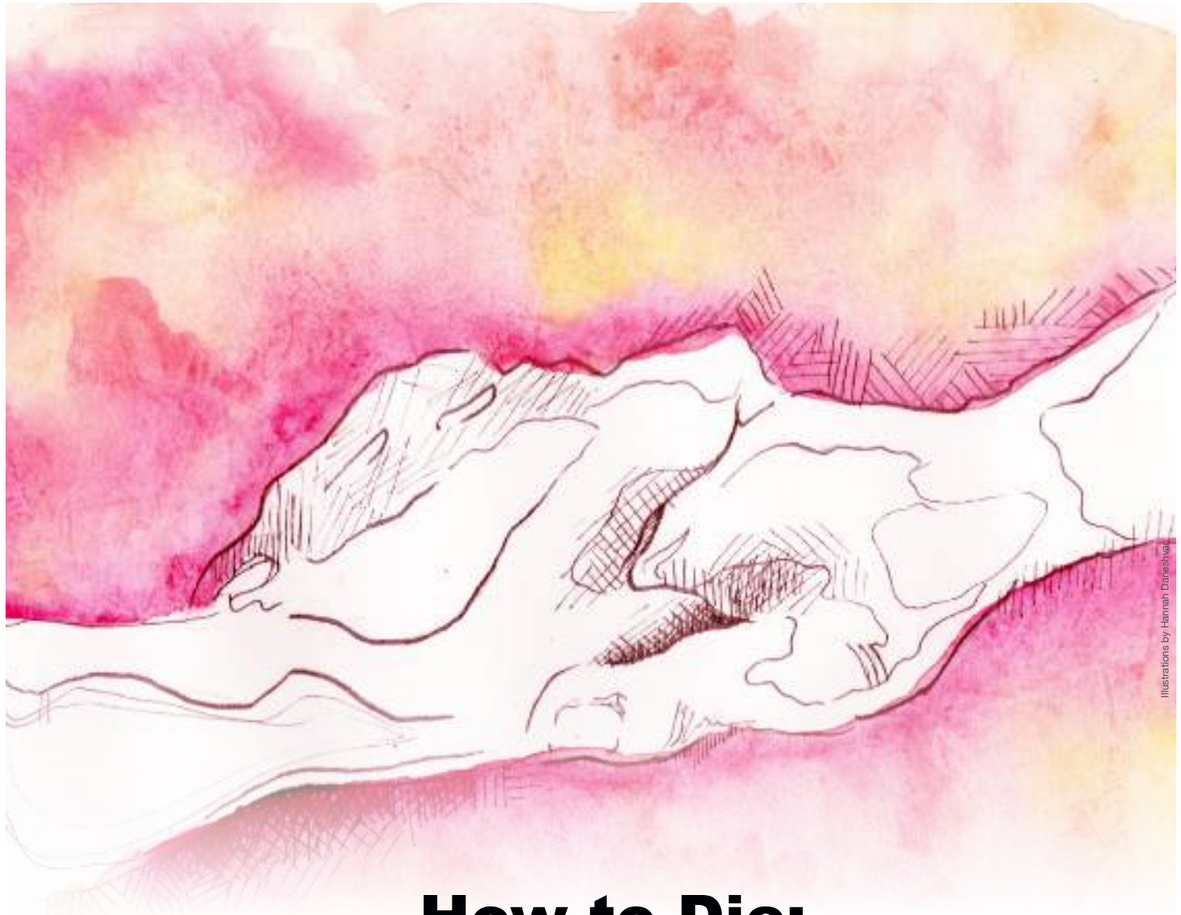
Richard Layard, the pre-eminent happiness economist today, writes, "By happiness I mean feeling good – enjoying life and wanting the feeling to be maintained. By unhappiness I mean feeling bad and wishing things to be different." Ed Diener, another prominent researcher, proclaims that a happy person is one who "experiences life satisfaction and frequent joy, and only infrequently experiences unpleasant emotions such as sadness or anger." It is clear that the happiness these researchers seek to quantify is of the hedonic variety. It shouldn't be surprising then that "relaxing, shopping, watching TV, socializing and having sex" are associated with higher levels of happiness, while "household work [and] professional work" are associated to lower levels of happiness.

This might be small potatoes if governments weren't poised to use these metrics as a guide to governance, but given that this seems to be a real possibility, the emphasis of hedonic happiness over eudaimonic happiness is a real concern. If governments incorporate hedonic happiness measurements to estimate the efficacy of their policies, the policies lauded as most "effective" will almost invariably earn this title by giving more weight to the transient, more quantifiable forms of pleasure instead of encouraging citizens to take the path less traveled. An MDMA subsidy is only a few steps away.

But Hey

Richard Feynman is often attributed the quote, "Philosophy of science is as useful to scientists as ornithology is to birds." It's not clear who first replied, that ornithology would be of great use to many birds.

This article is not attempting to disqualify a new, exciting fusion between economics and psychology. Happiness research is bursting with promise, and even its most inchoate insights are beyond interesting. But as happiness metrics gain traction as a way to measure societal progress and direct government policy, it's important to understand its limits and especially its dependence on implicit assumptions. As long as we're going to build a new scientific vehicle to steer society forward, let's also be sure to examine the road.



Illustrations by Hannah Daneshvar

How to Die:
The Limits of Modern Medical Technology

By Katrina Lettang

At 9 PM Friday night, I entered the emergency room, wearing my blue scrubs with an EMT badge clipped to the front pocket. As I passed the rows of patient rooms, the usual sounds and sights bombarding me, I gathered the sense that this shift would be a hectic one — full of overdoses, alcohol poisonings, and gun shot wounds. When I spotted an elderly man in a dimly lit room, however, my assurance faltered. Driven by curiosity, I stepped inside and knew instantly that this man, completely alone and hooked up to bundles of tubes and wires, had come here to die.

The ER was packed with patients, but I decided to sit with him and listen to his story. He spoke between breathless wheezes, his voice wet and crackling. I wrapped my hand around his, noting the frailty of his limbs and how tissue paper skin sunk away from his bones, cracked and bleeding. Some parts of his skin were so thin that blood broke through and stained the sheets. Twice, a nurse stepped in to check his vitals, but each time always left promptly, without a word. He died an hour after I arrived, the grip of his hand loosening around mine.

I drove home from my shift at 5 AM, his face and voice seared into my brain. Though I felt moved by the experience, I also felt confusion. I began to question the purpose of medicine. I had always thought that medicine strove to improve the quality of life, not extend its quantity, yet the hour with the man in the ER room made me think differently.

The development of medical technology over the past century partially explains this new attention to life extension. From the Human Genome Project to the utilization of antibiotics, our recent medical advancements have saved millions of lives, and the discoveries show no signs of stopping. As a result, the average life expectancy in the United States has risen from 69 to 78 years in just half a century. The caveat, however, is that these achievements instill the false reassurance that with medicine, we can avoid death indefinitely. When the terminal diagnosis comes, we believe our technological advances will overcome it.

Sure enough, fighting off a serious illness and winning is possible. Of the 44,030 people in the United States that are diagnosed with pancreatic cancer each year, seven percent will continue to live for at least five years. However, most will face futility when medicine fails to save their lives. The problem is, no patient knows whether they are part of that seven percent or not. So when does the treatment of a disease become futile? When do IV fluids, ventilation, feeding tubes, and dialysis turn from treating a disease into prolonging death?

To understand why interventions used to treat patients are also used to stave off death, Jad Abumrad and Robert Krulwich of WNYC's Radiolab took to the streets of NYC to ask people their hypothetical preferences, were an irreversible brain injury ever to befall them. The vast majority said they would consent to all possible procedures, including breathing machines, major surgery, ventilation, dialysis, and chemotherapy.

While many people outside the medical profession are quick to ask for these procedures, a doctor is much less likely to agree to most of them. Joseph G. Gallo, a professor at Johns Hopkins University, came to this very conclusion in a portion of the Precursors Study. Of the 765 physicians that responded to the survey, which included the same hypothetical scenario as Abumrad and Krulwich's street study, ninety percent declined CPR, dialysis, and ventilation. Sixty percent even declined antibiotics. The only medical intervention that the majority (80%) of doctors consented to was pain medication.

The differences in preference between medical professionals and people outside the medical field are striking, which raises the question: why? What leads to such a wide gap in the desire to consent to potentially life-saving procedures? With great insurance and plenty of personal connections to doctors who specialize in difficult diseases, it might seem like a waste for a medical professional to forego treatment. Dr. Ken Murray, author of How Doctors Die, proposes an explanation of the preference of doctors to seek far less medical intervention than the average patient. He argues that a doctor's "inside" view of the medical world may be the very reason for their choice against undergoing these procedures. Doctors see the effects of futile care every day. They know exactly what it is and exactly what it does to their patients. They bring in the most cutting edge medical technology because their patients demand it or because it would be illegal to do otherwise. "The patient will get cut open, perforated with tubes, hooked up to machines, and assaulted with drugs," Murray states. "All of this occurs in the Intensive Care Unit at a cost of tens of thousands of dollars a day. What it buys is misery we would not inflict on a terrorist."

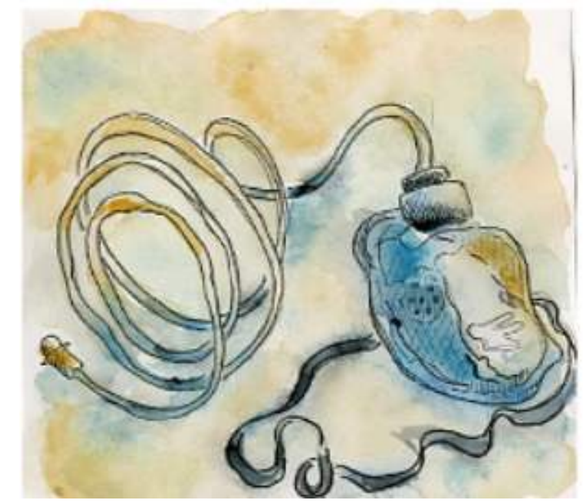
If doctors know the magnitude of pain and suffering they will put patients through in these procedures, why do they not intervene? Murray reasons that doctors often fear litigation if they present their personal judgments to a patient. Additionally, introducing the idea of death to a patient and their family is difficult. The family may not know the doctor, as is probably the case in an ICU or ER, leading them to believe that they are trying to save time or beds by advising to forego treatment. And yes, the fee-for-service system often leads to the encouragement of excessive medical care to make money.

Mostly, the reason for the average patient's choice to continue with futile care lies in an overconfidence in medical technology itself. When a doctor confronts a patient about the stark realities of their condition, the patient will likely choose to proceed with the treatment because of hope, because surely medical technology is advanced enough to cure them. Atul Gawande, a journalist, surgeon, and associate professor at Harvard Medical School, explains the problems with this sentiment in his article "Letting Go". "We've created a multitrillion-dollar edifice for dispensing the medical equivalent of lottery tickets — and have only the rudiments of a system to prepare patients for the near-certainty that those tickets will not win. Hope is not a plan, but hope is our plan."

The danger of hope as a plan lies in how it can blind a patient from the truth of medical technology. In fact, most people are unaware of how infrequently it works and how painful it is. For instance, many people are unaware that CPR often cracks the sternum and ribs when done correctly. Even more disheartening, CPR revives people back to a meaningful life only about 2-10% of the time, though medical TV shows exhibit an impressive 75% revival rate. Ventilators often lead to anxiety, pain, and delirium, which are usually treated with sedatives and paralytics. The experience of life support in the ICU is even so stressful and traumatic that 20% of those that leave the ICU will experience symptoms of post-traumatic stress disorder.

When I think about how I want to die, the words "peacefully", "painlessly", and "not alone" come to mind, as they mostly likely do for most. Yet whenever I transfer another patient from the ER to the ICU, I feel a sickening mixture of hope that the patient will pull through, and dread that they will die here in the exact opposite way they wanted. In this way, medical technology has utterly failed those who need it most. There must be a better approach to futility that meets the needs of the dying and pulls us away from the quantity of life over quality of life sentiment.

Over the past few years, palliative and hospice care have become more popular among those facing death. In lieu of drug therapies and invasive



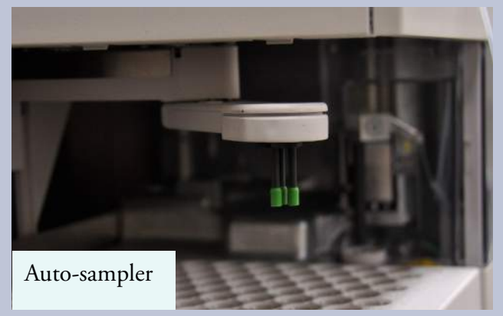
medical procedures, these fields focus on alleviating suffering and giving the patient a full, end of life experience. In a 2008 study conducted by the national Coping with Cancer project, researchers concluded that those in hospice care experienced a substantially higher quality of life in their final week than those in the ICU. Furthermore, close family members were much less likely to suffer from major depression. Surprisingly, when medical treatment is halted and patients turn to hospice or palliative care, they actually live longer.

The lesson is practically zen. The less we stop trying to lengthen our lives, the fuller lives we will live. Seven out of ten Americans will die from a chronic disease and 80% of patients say they don't want hospitalization or intensive care in their final weeks, yet more than half of us will end up dying in a hospital just like the man I met that Friday night. More truthful than any projected statistic however, is the fact that death will eventually come for all of us, and the greatest medical achievement of the century will not be learning how to stave it off, it will be learning when to accept it.

Liquid Chromatography Mass Spectrometry

By Holden Lai and Tommy Tullius

The LC/MS, acquired in 2007, is an analytical instrument used for the separation and identification of different chemical species. The instrument has two parts: liquid chromatography and mass spectrometry. The liquid chromatography component is capable of physically separating mixtures of chemicals and the mass spectrometry can give mass analysis and quantify the separated chemicals.

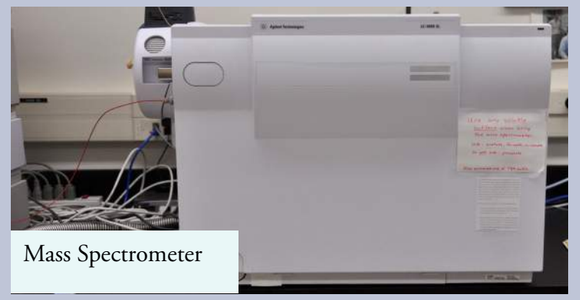


Auto-sampler

In the liquid chromatography column, compounds are separated based on their affinity to the solvent, known as the mobile phase, and the resin on the column, known as the stationary phase. Compounds with stronger intermolecular interactions with the stationary phase will be retained on the column for a longer period of time while compounds with stronger intermolecular interactions withe the mobile phase will come off the column first.

LC Column

After the compounds are separated, they are ionized in the mass spectrometer and the masses of the ions are recorded.



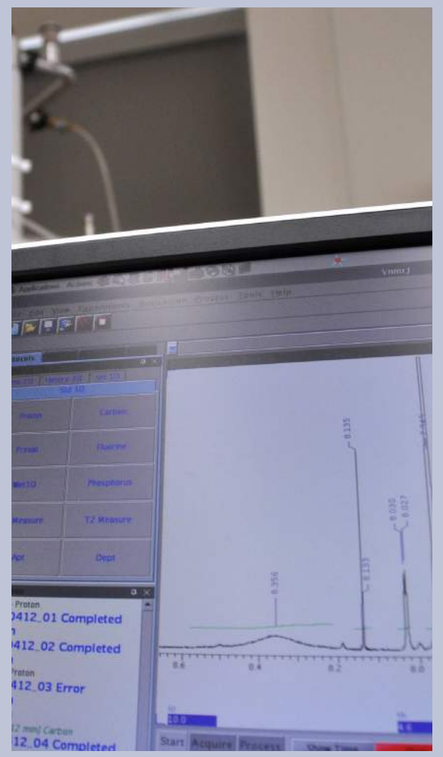
Mass Spectrometer

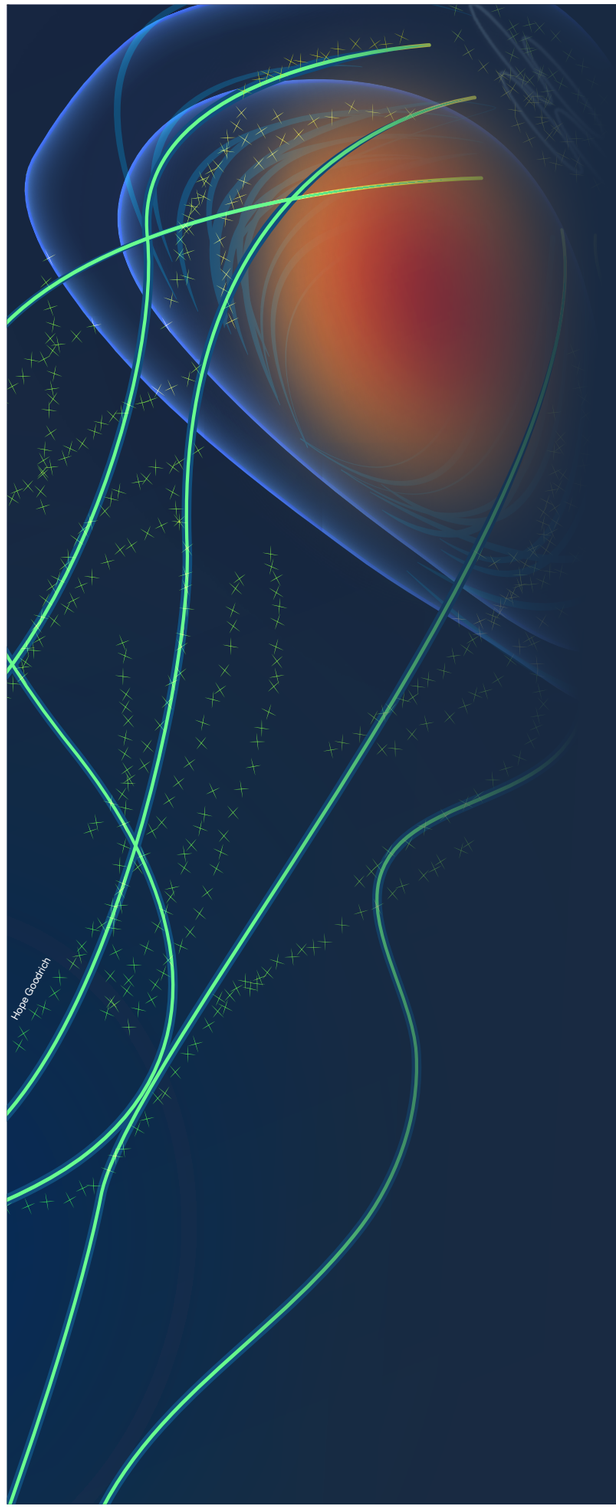
Why you need one in your house:
Because of the high sensitivity and selectivity of the instrument, the LC/MS is very powerful in detecting and quantifying various chemicals. If you ever wonder how much caffeine is in your coffee, simply brew a cup, add in a known amount of ^{13}C-labeled caffeine to the coffee, perform a solid phase extraction to extract the caffeine, and then put in through the LC.

Nuclear Magnetic Resonance Spectroscopy

The NMR spectrometer, also acquired in 2007, is a very powerful instrument used primarily for the elucidation of chemical structures. In an NMR spectrometer, a constant magnetic field causes nuclei to align in a certain way.

Why you need one in your house:
When you buy caffeine pills, how do you know that they are actually caffeine pills? Dissolve the pill in a deuterated solvent, take a proton NMR, and compare it with the spectrum on SciFinder!





Everlasting Organisms

By Alix Jason

Immortality is not just for Tuck Everlasting; it is a reality for some creatures. It may seem bizarre that amongst us there are organisms that evade death, for whom evolution has figured it all out. These organisms are not strange aliens that we have never heard of; they are in fact common creatures that have only recently been studied in depth.

One such seemingly simple organism, Turritopsis nutricula, nicknamed the "Immortal Jellyfish," was only first reported in 1996. Before that, little to nothing was known about its fascinating life cycle. The adult grows only to about ½ centimeter long. Their original habitat is in the Mediterranean, but lately they have been migrating to waters around Panama, Spain, Florida, and Japan.

These jellyfish appear in one of two body shapes: the medusa, which has the umbrella shape we commonly think of for jellyfish, or the polyp, which looks like an elongated version of a jellyfish. Medusas give birth to polyps, which in turn reproduce asexually and then bud off into new medusas. This is a pretty normal life cycle for a Cnidarian, but this is not even the half of it for the Immortal Jellyfish. When this jellyfish is in its medusa form, it possesses the potential to revert back to the polyp form, essentially starting its life over again.

This transformation from medusa back to polyp is usually triggered by environmental stress or attack. For example, a jellyfish that has been maimed by a predator would typically go through this regeneration. After the attack, the medusa falls to the ocean floor and its body expands. The tentacles disintegrate and then the entire body mass shrinks into a small ball. Within three days or so, the stolons sprout again out of the central body. Two days later, the jellyfish emerges from the bottom of the ocean as a fully formed polyp. It is now ready to take on the world yet again.

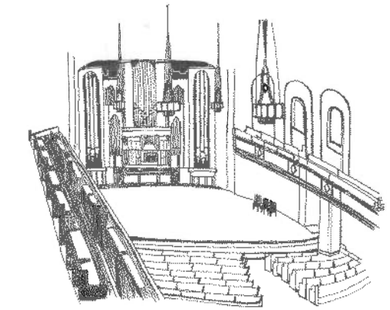
So, how exactly does this whole immortality process happen? A lot of it is due to the phenomenon of cellular transdifferentiation when one type of cell switches functions and changes into a different type of cell. This is the working mechanism behind stem cells, which are unspecified cells that can develop into a whole array of cell types. This means that when the jellyfish falls to the bottom of the ocean, its cells essentially "forget" what their prior functions were and become undifferentiated again. In the process of recreating the polyp form, the cells assume new functions.

Although jellyfish are obviously physically different from human beings, the Human Genome Project has indicated that we are in fact pretty similar to jellyfish. Humans possess around 23,000 genes, the same number as a roundworm. In contrast, jellyfish have many more genes than was predicted. The good news is that because we are so genetically similar to jellyfish, scientific research is more easily transferable between species. Jellyfish also possess microRNA, which helps determine gene expression and aids stem cells in becoming specified cells. Improperly functioning microRNA is thought to be one of the causes of cancer in humans and other organisms. MicroRNA play a large part in the regenerative abilities of the Immortal Jellyfish. Studying these organisms could give researchers more insight into the workings of microRNA, potentially helping with cancer research. Currently, there is only one man, Shin Kubota, who calls himself a specialist on Turritopsis nutricula, and he is living and studying the world's only captive population of these jellyfish in Japan. In his research he has found that over a two-year period, a colony of these jellyfish regenerated ten times.

Although the world may not be familiar with this tiny jellyfish, lobsters can also be immortal. Lobsters exhibit indeterminate growth, which means that if they are given a large enough space and proper nourishment they will continue to grow indefinitely. Along with indeterminate growth, they also exhibit negligible senescence, meaning they do not show signs of aging. Their bodies neither show signs of decay nor do their bodily functions slow down. There is virtually no evidence indicating that lobsters die of old age. All of the causes of death are related to injury, disease, or predation. Researchers theorize that in the proper environment, lobsters could be immortal.

The secret to their longevity is the presence of telomerase during cell division and stem cells in all of their body tissues during their entire life span. When cells divide in mitosis, DNA can get damaged in the process. Telomerase is an enzyme that produces telomeres, which protect important DNA from damage. It is thought that in humans, telomere degeneration is part of the natural aging process. Lobsters manage to avoid this part of senescence.

There are a few more organisms thought to be immortal (Planaria, Tardigrades, bacteria, and Hydras) and scientists theorize there could be more out there. So, why haven't these species been getting attention from scientists and the media? One of the main reasons is that these organisms are relatively tiny, and tiny organisms are generally studied less than larger ones. Typically, there is not enough funding available to researchers who want to study miniscule organisms that are seemingly very different from humans. However, immortality may be a game changer, inspiring scientists to spend more time on these creatures, figuring out how they manage to survive and how to use these discoveries to better understand human diseases and our own aging process.



The Science of Acoustics

By Emi Ostrom

When designing buildings, the ideas of architects often conflict with those of acousticians. The building materials and dimensions of a given space determine the qualities of its acoustics; for example, a large, narrow room with a high ceiling and stone walls will be extremely reverberant. In an outdoor hall, an acoustician would design the arena so that the audience is seated on a step incline, with the people at the back significantly higher up than the people in the front. This is because human bodies absorb significant amounts of sound when they are all at an equal elevation. Arenas with a truly clever design have seats that are roughly the size of humans, so that the acoustics with the presence of a full audience and an empty house are not terribly different.

When we hear a sound in an enclosed room, we are actually processing a combination of direct sound and delayed or distorted copies. There is always a time delay between when a sound arrives at one ear versus the other, and neurons in the brain average these cues together to help us localize the origin of the sound. If the direct sound is louder than the sound being reflected off of the walls and ceilings, then listener perceives the sound source to be directly in front of them.

Different reverberation times may be desired, depending on the purpose of the space. Recording studios, for example, aim for a 'dry' acoustic with little to no reverberation, whereas organists prefer a reverberation time of 5-10 seconds. People standing close to the sound source hear mostly the direct sound with very little reverberation; vice versa for those standing very far away. Therefore, by creating a space without reverberation, recording studios create an illusion of auditory intimacy.

Research has shown that humans have a consistent subjective preference for 'interaural dissimilarity': when a single sound enters the two ears at slightly different times. This means that narrow halls provide more satisfying acoustics because they create more lateral reflections. The listener feels 'enveloped' by the music, rather than separated from it.

When a sound wave hits a wall, part of that wave is reflected and sent back out into the room. The other part continues to travel through the wall, distorting the material and eventually converting from kinetic energy into heat. Every type of building material absorbs a different amount of sound, known as its 'absorption coefficient'. More absorbent materials function as sound mufflers. Absorption coefficients vary not only by material, but also by frequency. For example, carpets absorb 2% of the sound at the low frequency of 125 Hz, but 60% of the sound at 2000 Hz. Glass and plywood are the opposite, absorbing much greater amounts of sound at lower frequencies. Thick materials like brick and concrete have very low absorption coefficients no matter what the frequency.

Absorption coefficients determine two important acoustical qualities: the reverberation time of a room, and the ultimate loudness of a sustained sound. To understand the latter concept, imagine holding down a note on an organ. If the note were sounding in a room of highly reflective materials, it would be able to become extremely loud because most of the wave would be directed back out into the rest of the room. A room of highly absorbent materials would suck most of the sound into the walls, thus resulting in a lower overall volume.

The architecture of acoustics follows us everywhere; any time you've attended an opera in Hall Auditorium, sat through a concert in an outdoor arena, or recorded a song in one of the Conservatory practice rooms, your auditory experience has been engineered by an acoustician who shaped the space to subtly manipulate the power of sound.

Neuromarketing: Exciting or Evil?

By Gabe Marx

Paul Miller Gamble

Companies are more than willing to spend buckets of cash to find the perfect way to sell their product — $168.5 billion were spent on marketing in 2012 in the U.S. alone. Critical to this pursuit is an understanding of the human mind and behavior, and for a little more than ten years, some neuroscientists and psychologists have been lending their skills to the task.

It seems only natural that the business of marketing research serves as a commercial pursuit for psychologists. John Watson, arguably the most prominent figure in American psychology of the early 20th century, left his academic pursuits to become one of the greatest advertisers in history. He would go on to popularize the term "coffee break" during an ad campaign for Maxwell House coffee.

Recent years have seen a paradigm shift for psychological pursuits like Watson's. Researchers have gone from observing external behavior to observing the brain directly. This same shift is reflected in the business of marketing; marketing executives employ cognitive neuroscience techniques, such as fMRI, to sell their product. This new set of marketing practices has become known as neuromarketing.

In the past ten years a number of savvy neuromarketers have appeared, making their case with eye-catching, multicolored images of brain scans that lend credence to their research. These neuromarketing consultants claim that their scientific expertise gives them access to a 'buy button' in the human brain, a trigger that will render any consumer utterly submissive to the whims of an advertisement.

Obviously, the pursuit of a 'buy button' is a fool's errand; the brain will never be that straightforward and accessible. Even scientists using fMRI imaging still struggle to analyze the simplest of cognitive functions. Simply put, cognitive neuroscience is far from obtaining the secret to total corporate brainwashing. It is easy to be drawn in by colorful pictures of brain activity and to believe that these images are rich in scientific content. In reality, though, the images which seduce advertising firms are highly processed, and hold little information accessible to any layperson.

Yet neuroscience can still make meaningful contributions to marketing, say its advocates. Neuromarketers argue that brain activity is a much better measure of how people feel about products than the (notoriously unreliable) traditional focus group. The self-assessment measures commonly used in marketing research rely on the ability and willingness of the respondent to accurately report their attitudes and habits. People's stated responses may not reflect their actual buying patterns, and it is impossible for a traditional survey to capture the emotional reasons underlying consumer preferences.

Brain imaging offers the promise of overcoming such hurdles, bypassing the difference between what consumers say and what they think. In a sense, these researchers are hoping to tap into the consumer's subconscious. According to neuromarketing advocates, such data can be put to use by companies to adjust advertising strategies or the product itself as means to maximize the appeal to consumers.

This kind of research has led to serious reconsiderations in advertising strategy. In a landmark study by Samuel McClure and Read Montague, the director of the Human Neuroimaging Lab and the Center for Theoretical Neuroscience at Baylor College of Medicine, 67 subjects agreed to go into fMRI brain scanner while taking the famed 'Pepsi Challenge', a blind taste test of Coca-Cola and Pepsi. The results of the taste test were not incredibly revealing, half the subjects chose Coca-Cola and the other half chose Pepsi. However, the imaging data of the experiment yielded some fascinating insights into the neural mechanisms of consumer choice. During the blind taste-test, subjects' preferences were significantly correlated to increased activation in the ventral medial prefrontal cortex — an area of the brain believed to be associated with the feeling of reward and pleasure — and divided evenly between Coke and Pepsi. This indicates that when left to pure sensory information, without knowledge of brand, consumers' decisions are solely governed by activity in these "reward areas" of the brain.

If this were the whole story, Coca-Cola and Pepsi would share equal parts of the market, yet this is not the case—Coca-Cola has dominated in sales over Pepsi for years. The researchers of this study believe that this can attributed to the way in which consumers perceive the brand. The most fascinating finding of this study was brought about when the researchers compared the brain activations in conditions where subjects knowingly consumed Coca-Cola to conditions in which subjects were oblivious to the brand. The researchers found increased brain activation in the dorsal lateral prefrontal cortex and the hippocampus— two areas in the brain that are believed to work together in the process of conjuring up representations of memories. This additional brand knowledge-induced activation was not found when the same contrasts were performed using Pepsi. The data indicates that when consuming Coca-Cola, our minds are flooded with the imagery associated with the brand through successful marketing—brilliant red cans sweating with condensation, vintage images of a rosy Santa Claus holding up a Coca-Cola bottle, an adorable family of polar bears building snowmen while enjoying Coca-Cola. Our buying decisions are not dictated only by what product tastes better, but also by the memories and experiences that the brand conjures up.

In another experiment, sponsored by carmaker DaimlerChrysler at the University Clinic of Ulm, Germany, researchers used fMRI to scan men as they looked at pictures of sports cars, limousines, and compact cars. The results revealed that when viewing cars culturally associated with wealth and prowess, subjects exhibited increased activations in a reward area of the brain called the ventral striatum. Interestingly, previous studies have shown that this area is involved in monkeys' perception of social dominance. The researchers believe that their findings indicate that modern humans use automobiles as a display of social stature in the same way that alpha monkeys flaunt their social dominance by displaying their teeth or beating their chests.

Uri Hasson, a cognitive neuroscientist at Princeton, is also applying this technique. Hasson uses fMRI imaging and EEGs to gauge the ways in which people enjoy film at a neuronal level, probing questions such as what components of film create suspense, fear, or excitement. His findings are then used to help strategically design movie trailers for maximum audience interest.

These neuromarketing applications can be used for a wide variety of purposes, and recently, political campaign managers have taken notice of their usefulness. To make more efficient political advertisements, a team of researchers from University of California, Los Angeles began placing both Republicans and Democrats in fMRI machines and studying their brains' responses to different stimuli, such as images of the September 11th attacks. The use of neuromarketing to make more effective campaign ads has given rise to many ethical concerns — using neuroscience to alter one's consumer decisions is one thing, using neuroscience to alter one's democratic choice is another.

As neuromarketing increases in popularity, concerned consumer advocacy groups have begun dissecting just how ethical neuromarketing really is. Brighthouse, an Atlanta-based consulting firm working with faculty from Emory University, was the first to give its services the title of 'neuromarketing'. Founded in 2002, the Brighthouse branch known as Neurostrategies quickly attracted criticism for potential conflicts of interest involving the use of Emory University equipment. The anti-advertising civic group Commercial Alert warned of "marketing-related diseases" resulting from the promotion of junk food companies, and called for a government investigation into Brighthouse Neurostrategies' research. The website for Brighthouse Neurostrategies was quickly taken down, and the firm's new branch faded from public attention.

Are the cognitive neuroscientists to blame for capitalizing on their scientific knowledge? For years they have sat by and watched as their molecular colleagues gained more and more opportunities to cash in on their skills. Neuromarketing presents the first opportunity for cognitive neuroscience to be used for commercial gain. Advertising is a lucrative business; it is estimated that each year $6.8 billion are spent on focus groups, opinion polls, and other marketing tools in the US alone. Can neuroscientists be blamed for trying to tap into these big budgets and sell their know-how to the highest bidder?

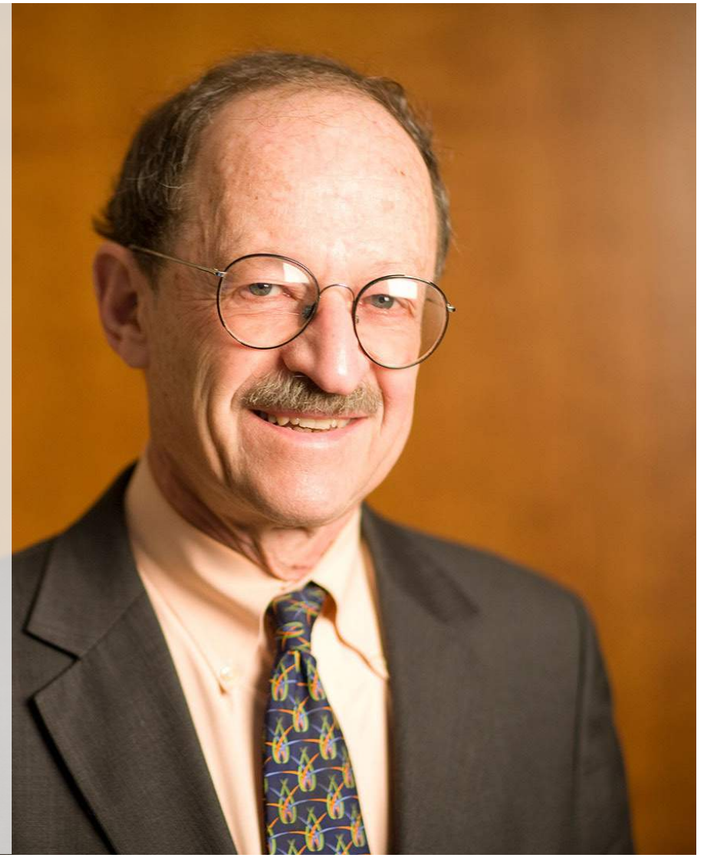
Considering the recent massive spending cuts to the NIH, cognitive neuroscience, a field whose research has no direct clinical applications, has taken a massive blow to its budget — and experiments using fMRI scanners were never cheap to begin with. The financial support provided by large corporations could lead to massive developments in cognitive neuroscience, deepening our understanding of the workings of the mind.

However, would this gain in knowledge be worth the ethical repercussions posed by successful neuromarketing? Donald Kennedy, editor-in-chief of Science, the nation's most influential scientific publication, told delegates of the Society for Neuroscience meeting in 2003 that he was very concerned that brain imaging would infringe on personal privacy to an unacceptable degree. Envision a society in which neuromarketing has fulfilled its wildest goals, and can successfully persuade anyone to buy anything and vote for anyone. Would the incredible discoveries about the brain be worth the social implications of their usage? It's too early to say for sure, but it is safe to assume that as the field of neuromarketing progresses and is increasingly implemented in our society, our ability to make decisions based on our own free will may fall deeper nd deeper into jeopardy.

An Interview With **Harold Varmus**

Nobel Prize Winner
in Physiology or Medicine

Director of the National Cancer Institute



Harold Varmus is the current director of the National Cancer Institute, a branch of the National Institute of Health. He graduated from Harvard with a degree in English Literature, later applying to medical school and working a physician in missionary hospitals in India. As an alternative to serving in the Vietnam War, he joined the Public Health Service at the NIH in 1968. He served as the director of the NIH from 1993-99, and was President of the Memorial Sloan-Kettering Cancer Center in New York City from 2000-2010. In 1989 he was awarded the Nobel Prize in Physiology or Medicine for his research on oncogenes, genes that have the potential to create cancerous cells.

Your career has taken you to a wide variety of roles at numerous institutions. How has your perspective on science research changed as your career has evolved?

Well you couch the question in terms of institutions, but two things have happened. Well, three. I changed, time went on, and I went to different institutions, so it's a little hard to answer to answer the question in a simple way. As I took on more responsibilities in running institutions I obviously scaled back my lab. And science has changed dramatically … because we know more and because there are new technologies that allow us to study things in totally different ways. Technology drives what science can do and there have some unbelievable changes – the big ones being the advent of recombinant DNA methodologies, DNA sequencing, new kinds of imaging, improved mouse genetics, transgenic animals, and then computation. Dealing with information through the internet has radically changed the way we get information about what's going on in the field.

Doing science today is, on the surface at least, a very different operation. I still believe that the fundamental principles of how science is done have not changed all that much. It's still a matter of accumulating information, asking good questions, trying to get an answer that makes sense, working on problems that have inherent importance. The other thing that's dramatically changed in my own field is the sense of closeness of the problems I work on … applications to human health and industrial opportunity. Those are obviously connected ideas, but there's no doubt that people studying cancer today feel as though they're only a couple of steps away from having a new way to diagnose cancer, a new way to treat it. When I was starting out we had such a primitive idea of what a cancer cell was, and how a normal cell became a cancer cell that I don't think anybody thought that … they were going to have a practical application of their work. If you wanted to do that you just went out to the clinics and you took whatever chemical poisons were being produced by drug companies and tried to figure out which ones were effective in treating certain kinds of known cancers.

What are your day- to-day activities like as the head of the NCI?

I don't want to give too much away here because people will think I'm lazy. I have a few principles: I try never to go to meetings I don't run. I have to go to a few because NCI is part of the NIH and I have to go to a few meetings led by the NIH director, but usually every meeting I run, so I set the agenda and I say it's time to break up. Number two, my staff is not allowed to start my day too early. Fill the calendar in from the back. I like having the morning to myself so I can ride my bike to work, have a coffee, take it easy, read the paper, get caught up on things. Number three, I never go to meetings to make opening remarks. They take a lot of time. I don't meet and greet, I just do things that I think are valuable. I try to keep my days interesting, with texture. I have a lab at the NIH and I try to get there a couple times a week. If somebody comes to give a scientific lecture, I get to go to a lecture a few times a week just to keep my brain cells turning over. Because I'm leading this peculiar life right now where my work week is very dense with meetings and I don't have a spouse with me, I tend to arrange dinners with interesting people, and so I have a little bit of social fun and also work on the side. And I try to put some science in every day, in one way or another.

As co-founder of the Public Library of Science (PLoS) and a board member of BioMed central, you're obviously a big supporter of open access publishing of scientific research.

Let me just make a little distinction between open access and public access. It seems like a narrow distinction but it pretty important. Public Library of Science is true open access – the author pays a fee, everything is available immediately, the author holds the copyright, things go into Pubmed Central, and the text can be fully used by anybody for anything – text mining, machine learning, anything as long as you provide adequate acknowledgement of where the work came from. With what NIH now has, which is a huge improvement … is that congress wrote a law that said that [via public access] NIH grantees must provide the peer-reviewed completed text [publicly] within a year after it's been published. So that means that there are literally hundreds of thousands of papers deposited into Pubmed Central ever year, and now there are several million and the world of the libraries of recent biomedical research results is very rich.

As the director of NIH, you authored a letter to the United States Patent and Trademark Office urging for tighter restrictions on access to gene patents, and there have been several changes to their policies since. What are your thoughts on the impending decision of the BRCA Supreme Court Case and do you agree with the current policy? [*Editor's note: BRCA1 and BRCA2 are genes which can be subject to a number of cancer-causing mutations. A private company, Myriad Genetics, was instrumental in isolating these genes and identifying many mutations, and filed a patent for the gene and its mutations, which has prevented clinicians from detecting mutations in these genes in potentially at-risk patients. The Supreme Court Case Association for Molecular Pathology et. al v. Myriad Genetics challenges the validity of Myriad's patents, and is currently still pending.*]

No. I'm strongly supportive of the plaintiffs [Association for Molecular Pathology et. al] in this case. You've got to distinguish between at least three varieties of DNA patenting. The two things that are almost certainly permissible to patent are DNAs that are created by some laboratory invention, whether its copying RNA to make DNA, creating something that's not in nature, making an unusual combination of DNAs through recombinant DNA engineering. There you're creating something that doesn't exist in nature, and those things are patentable. Now the value of the patents varies dramatically. The vast majority of the patents don't really have much value because somebody else can make something slightly different that avoids the patent but basically produces the same effect. So it's not worth spending the thirty or forty thousand dollars to pursue the patent.

What's at issue in this case is patenting the native gene, and mutant forms of the gene that occurs in nature. I think the case that this is patentable … is very weak. The decision went in favor of my position in the first hearing and the appeals court turned it around. It was remanded back to the appeals court by the Supreme Court, and they made the same 2 to 1 decision. Now the Supreme Court is going to hear it on April 15th and we shall see. I'm hopeful.

There are some complaints that cancer research funding is skewed towards breast cancer, as opposed to funding other cancers that are just as deadly. What are your opinions on that?

Well, I think you've got to be careful here, because it's certainly true that if you do a simple classifying exercise, there's more money that can be labeled as money for breast cancer research than for most other kinds of cancer research. I hesitate to even say it that way because if you start to categorize cancer research by disease, you're underestimating the complexity of the classification process. There are many different kinds of research. Some is clinical research, and clinical trials. Some is work on diagnostics, some is work on mammography. Some is work on animal models of cancer. Some is just trying to understand the nature of the genes that are involved in generating breast cancers. In that category in particular, there is a lot of fuzziness in the classification if you classify by disease. Many of the genes that are involved in breast cancer are involved in many other kinds of cancer. Many of the techniques that you might use to generate a mouse model of breast cancer, for example, are applicable to other problems.

There are folks who would like to think that you can take some metric for characterizing burden of the disease, the number of people affected, the number of people who died, the amount of suffering, the advances we've made, the likelihood of surviving five years, and make that into some kind of metric that should drive research funding. That just doesn't work well. First of all, the interoperability of information, application of one funding to another situation, is very hard to determine. Second, a lot of what we do has to be driven by scientific opportunity. For a lot of reasons, breast cancer is a disease that is easier to study. We have more tools, it's a cancer that arises frequently, it is detectible very early in human beings, we happen to have a lot of mouse models of breast cancer, and there are a lot of cell lines. That previous investment encourages working on breast cancer as a model. That's not to say it's all right, but it just complicates the analysis. There are many famous cases of really important things coming from working with a cancer that is either very rare in human beings, and the classic example is retinoblastoma. We made a lot of progress on that disease but it's always been a rare disease. The biggest thing that came from the study of that disease was the discovery of a whole class of cancer genes, called tumor suppressor genes that are immensely important in understanding all cancers.

What do you think about the recent "big science" projects, like the ENCODE project and President Obama's announcement about future plans for the "Brain Activity Map"?

I'm going to talk about that tonight!

Can I get a preview?

The deeper question you're asking is one that's not yet resolved. I think people ought to remember that all these presidential initiatives that made a difference were controversial at the beginning. First of all, when the president presented it at the State of the Union it was not phrased right, in my opinion. In the same sentence he talks about Alzheimer's disease, but that's not what this is about. … I think there's something here that could be big, but it just isn't worked out yet. It's just been decided recently that it's going to move out of the Office of Science and Technology Policy to the NIH. That was in the paper today, and that's important. Secondly, we don't know how we're going to fund it and we don't know what it is. This only works well when you set some goals, and there aren't any goals set yet. But the idea of taking on the human brain in some special way and generating public enthusiasm – you'll see today. The subliminal part of my talk today will be about how presidential enthusiasm for some scientific project drives science more generally, whether its moonshot, or war on cancer, or genome project. This is good for science, to have somebody standing up in front of the nation saying, "Yeah, let's go for this huge scientific goal."

Interview by Daniel Starer-Stor

An Interview With **Lisa Randall**

Professor of Theoretical Physics at Harvard University
Co-author of the Randall-Sundrum theory of String Theory

Named as one of Time magazine's 100 Most Influential People Lisa Randall is a theoretical physicist, best-known in the scientific community for the creation of the Randall-Sundrim models of 5-dimensional warped geometry. Randall currently studies particle physics and cosmology as a professor at Harvard University, the third university, besides Princeton and MIT, where she was the first ever tenured female theoretical physicist. In addition to her scientific work, she has written multiple books, including Knocking on Heaven's Door: How Physics and Scientific Thinking Illuminate the Universe and the Modern World *and M*ysteries of the Universe's Hidden Dimensions*, which were both included on the* New York Times*' 100 Notable Books of the Year list. Additionally, Randall wrote the libretto for the opera* Hypermusic Prologue: A Projective Opera in Seven Planes *and co-curated an art exhibit,* Measure for Measure*, for the Los Angeles Arts Association.*

What is super symmetry?

Super symmetry is actually an extension of the symmetries of space and time, the symmetries that say things look the same in every direction or at any time into the quantum regime. The actual physical consequence is that for every particle we know about, there is a partner particle that will have the same charge and mass.

What would the consequences of super symmetry be if the LHC fails to detect supersymmetric particle?

It would mean it's probably not relevant to the hierarchy problem of particle physics, which is the problem of why masses are what they are. Right now the question isn't just whether super symmetry exists, but whether super symmetry exits and is broken at a scale that is relevant to the physics being explored with the LHC. So, if it's not there, it's probably not by itself an explanation for why masses are what they are.

I was wondering if you could go into some specifics of the more experimental evidence of the Randall-Sundrum model?

It really is induced particles called Kaluza-Klein particles – particles that have momentum from the extra dimensions. And which particular particles you would find, depend on the details of how it's implemented. It also has consequences, potentially, for how particles acquire their masses, I'm sorry, for what mass relationships come about, but that would be harder to test. Really the best test is the Kaluza-Klein particles…named after the physicist and mathematician who first thought about extra dimensions in terms of physics.

Can you talk about your involvement with the physics opera you mentioned during your presentation?

I actually wrote the libretto, I didn't say that. I wrote the libretto and sort of helped design the story. I worked pretty closely with the composer, and also with the set designer, Matthew Richie. And [composer] Hector [Parra] and I communicated and had a concept of what we wanted it to be. I wrote some stuff he said, you know, you have to make it this way for my music – shorter phrases – and it's an opera, they should talk to each other more. So, it was a nice back and forth process. In the end, I think it had more physics than I would have done, but that was in part because he really wanted it for his music.

Is there an artist's statement with the opera? And if so, do you know what it is?

I don't think there is an actual artist's statement. Although there might be – probably Matthew has an artist's statement, he usually does. … I think we each had slightly different object goals in doing this, so I don't think there's necessarily a single artist's statement. But I think Hector was trying to explore both, you know, musically what you can do, and really use it as a way to expand. I was interested in telling the story through music and visual images. And Matthew was interested in doing that, too, I guess, at some level.

I'm sure in interviews you get asked to talk a lot about women in the sciences. Approaching it in more of a broad way, I'd like to know – There are different perspectives on this notion that women are underrepresented in science. Some people think that even if this is the case, it's not necessary to talk about it and we've moved past that era and even if they are still underrepresented, we are making progress. And then there's other people that say, no, it does need to be talked about, we need to find a solution. Which one of those perspectives do you think you lean towards and if we need to talk about it, who should be the people to be responsible for leading the conversation?

Those are really good questions. No one has ever phrased the questions those ways, so I think it's even good that people should be asking those particular questions. It's really not true that all the problems are solved. Yet, are they going to be solved by people talking about it? That's not clear. If people are talking about it who are really trying to find solutions, that's one thing. There's a lot of people who talk about it, just because they don't want to talk about physics, find it easier to talk about physics. Those people I have no interest I talking to. I think there are issues, but I think the issues are broader than just the sciences, and so they're really difficult questions. I don't think we're necessarily going to solve them but just looking at in the context of science. But there are some basic things that can probably help out. Like noticing that questions from women will be more dismissed, for example, or they'll be interrupted. So, there's some basic stuff worth talking about, because when people are aware of it, they'll do it less.

I certainly don't think we're past the time where everything is solved, but I don't think just talking is going to solve it either. And I don't know who should be. I think people with influence probably should be, but they should probably more being doing things about it. But it's just not so simple, because it's not something someone can impose on things. People have to decide for themselves. .. So I'm hoping just by making science accessible and making people see people doing science, that that's enough of an incentive that women and men will want to just do it.

There's all these competing theories to solve the hierarchy problem. Speaking abut gravity, specifically, there's symmetry, extra dimensions, entropic gravity, and Technicolor. What do see as the most compelling evidence? The most experimental evidence?

There's no experimental evidence for any of them yet. ... Experiments are going on [currently]. It's true, there's theories of super symmetry that really fit everything … I like the theory of extra dimensions, but that doesn't make it right. It's just a matter of opinion [at this point], but it will be really interesting to see what the data support.

You mention in your talk that one of the principles you really like is economy, and you mentioned that you were kind of wary of the approach of beauty as symmetry over just beauty in general in physical theories. What do you think about that in terms of theories like string theory, which have been predominantly based on their aesthetic appeal?

Right. So it's a very nice mathematical theory, and the question is how we connect it to the real world, which is still challenging. And so the question isn't just how you find a symmetric theory, it's how you find a beautiful, slightly broken symmetric theory, so that it can actually describe what we see.

You stated that most mass in the universe is contributed to what is not reported by the Higgs mechanism. Why do you think it is often reported in this way?'

Because I think that people just don't understand. Because … they're told the Higgs boson is associated with mass. I went out of the way to explain it [in the talk], because it's a little complicated. I think it's just simple to say the Higgs boson gives mass, and its sounds simple, but it's not actually the way it works.

You also talked a lot about this historical tend for scientists to think they've discovered the ultimate rock bottom, so to speak.

Not just in science – in just about everything. People always think they know the answers.

Right, and one thing that seems to be a popular notion for people outside the scientific community, when they demonize the sciences, is that scientists think they know everything. Science is so lofty and has so much hubris, to think that we can just say that these things are true. Why do you think that's the case, when the scientific community is trying so hard to show that what we actually care about is asking questions?

Well, I think some of it is self-imposed. It is true that in the context of science, scientists … will sometimes overstate their case. I think of it a little bit like lawyers, you know, they argue their one point of view. I think it sometimes it's simpler to just say what your point of view is and then let someone else tell you where you're missing something. But I do think that sometimes people, when they're talking about other areas – say, women in science – think they know everything. And they don't.

I think that scientists, or at least physicists, are by nature more combative. We ask questions. We have seminars, we interrupt during seminars, and at other places they don't and that's considered rude. I actually think that a lot of the time, we're just trying to get to the truth, but they're things that are considered arrogant. So, I think sometimes it's a misinterpretation. And I think that sometimes scientists socialize a little differently.

But I think sometimes, it's because people really do think they know everything. A friend of mine once said this about all academics – they said that academics are really funny, you know, because they're like the most secure and the least secure people in the world. And there's some truth in that. You have to really believe you're going to find answers but you also have to be questioning them if you're going to get to the right answer.

In terms of answers that we don't quite yet know, you emphasize that on ordinary scales we really do understand the physics and laws that govern everyday life, fundamental laws, but that doesn't mean we know how to put it all together. People often point to things like consciousness or the property of life even as being things we don't understand. Do you see something fundamentally different about these types of questions of complexity?

Yeah, I think that everything is different. The questions we ask are different; the methods we use are different. It's a really different notion of understanding and we haven't gotten there yet.

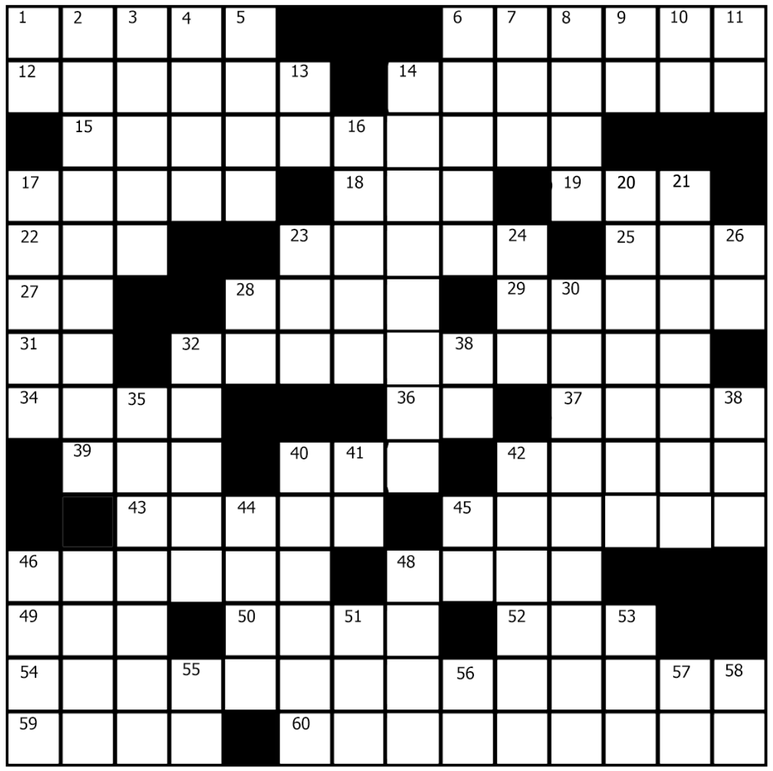
So how would you communicate that idea that knowing the fundamental laws doesn't necessarily mean that you can know these complex phenomena?

So, I actually talk about that in the book. I talk about even music – we understand fundamentally, about how we hear things with our ears… as oscillating air, but the fact is that's not what music is, so you clearly need a different level. And that's one of the places where scale comes in, because you really do need a different description to explain what that is. It doesn't mean we have that yet.

Press Conference Interview by Sujoy Bhattacharyya, The Oberlin Review, *and* The Grape

Crossword Corner

By Daniel Starer-Stor and Anna Dardick



ACROSS

1.Procedure for preg. people
6. Like a metal, in solution
12. Gutsy?
14. The answer is right in front of you . . .
15. Product of saponification
17. Birdbrain, in Egypt
18. Lays the products of 30-down
19. Electric discharge through air
22. Prefix of many Obies' concerns
23. Most reactive noble gas, practically
25. Instrument of naval propulsion
27. Surges just before ovulation (abbr.)
28. Fermented Japanese paste
29. With "foot," epidemiologically
31. Calculated by Archimedes with a 96-gon
32. Inventor of CLARITY and optogenetics
34. Paulo is one, in Brazil
36. Used in night vision tech.
37. Dept. related to 40-down
39. Obscure unit for enz. activity
40. First three ingredients for a fun 44-down
42. You all, probably (and us)
43. May render invisibility
45. Your body, after injection of 54-across
46. Performs the duties of an OB/GYN
48. Australian colloquialism
49. With (+), an important part of OXPHOS
50. Ultimate progenitrix, in antiquity
52. When doubled, a vector of disease
54. Neurotransmitters of the parasympathetic system
59. All tenured professors have these, and maybe you will too
60. Sulfur, so good . . . and a carbonyl

DOWN

1. Favorite of Tesla
2. Fourth ingredient of 40-across
3. Dept. that studies 14-across
4. Standardizes the curie
5. Insult for clumsy people
6. With "bacteria," the original chloroplasts
7. Raggedy doll of childhood
8. Box responsible for trans. regulation
9. Pull-down, in biochemistry
10. Ubuntu, e.g.
11. Bright light of B-way
13. Second smoggiest metropolitan area in the US
14. Narrowing of a blood vessel
16. Activity in which you may build a castle
17. Refrain of The Beatles, and many Honors students
20. Devices to coordinate network traffic
21. Site of reduction in a galvanic cell
23. Number of chromosomes in slime mold, to Julius
24. May display split peaks
26. Factor responsible for newborn's hemolytic disease
28. Short-hand for smallest alkyl group
30. Ovaries do this
32. Birth advocate, often uncertified
33. Show written by Michael Crichton
35. Came to an agreement
38. Molecule advocated by Timothy Leary
40. Comes in pillow type
41. Domain abbr. for a Scandinavian country
42. Stinging herbaceous plant
44. 48-across, as a group activity
45. There is at least one in most lab sections
46. Sound or stamp
47. At the speed of sound
48. When doubled, fit for pescetarians
51. Start of a jelly-donut assertion
53. Botany might be more interesting if this were real
55. Good leaving group, with an O
56. Amazingly, prefix for immature haploid
57. Writer of "has the naughty thumb/ of science prodded/ thy/ beauty"
58. Can be rough or smooth, in a muscle (unrelated to 44-down)

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/syn·apse/ *noun* **the point at which a nervous impulse passes from one neuron to another**

The Synapse is a relay point of science-related information with a twofold objective. First, we aim to stimulate campus interest in science by exposing students to its global relevance and contributions. Second, we strive to facilitate collaboration between members of the Oberlin College community, especially within the math and science departments.